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VOL. 119

"EVERY MAN IS A VALUABLE MEMBER OF SOCIETY WHO, BY HIS OBSERVATIONS, RESEARCHES, AND EXPERIMENTS, PROCURES KNOWLEDGE FOR MEN"—JAMES SMITHSON

(PUBLICATION 4384)

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LEONARD CARMICHAEL,
Secretary, Smithsonian Institution.

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VOLUME 119, NUMBER 1

Charles D. and Mary Vaux Walcott Research Fund

CAMBRIAN STRATIGRAPHY AND PALEONTOLOGY NEAR CABORCA, NORTHWESTERN SONORA, MEXICO

(With 31 Plates)

BY
G. ARTHUR COOPER
A. R. V. ARELLANO
J. HARLAN JOHNSON
VLADIMIR J. OKULITCH
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CAMBRIAN STRATIGRAPHY AND PALEONTOLOGY NEAR CABORCA, NORTHWESTERN SONORA, MEXICO

INTRODUCTION AND STRATIGRAPHY

By G. ARTHUR COOPER

United States National Museum, Washington, D. C.

AND

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Instituto Geológico de México, México, D. F.

(Plates 1-5)

Prior to 1941 Cambrian rocks were unknown in Mexico. But in that year Isauro G. Gómez L. and L. Torres, while making investigations for Petróleos Mexicanos, discovered trilobites in the Arrojos Hills 12 miles west-southwest of Caborca. The Mexican geologists sent their specimens to Dr. Alexander Stoyanow, University of Arizona, who identified them as Middle Cambrian trilobites. The published report of this discovery stimulated interest in México and in the Smithsonian Institution, long a leader in Cambrian stratigraphy and paleontology. The Smithsonian Institution therefore sent G. A. Cooper, representing its staff, and Ing. Alberto Arellano, representing the Instituto Geológico de México, to Caborca, Sonora, to investigate the reported Cambrian and other Paleozoic deposits. Happily, these geologists easily located the trilobite beds in the Arrojos Hills, but in addition they found several other areas exposing Cambrian rocks, especially one long and unbroken sequence 6 miles west of Caborca. Here Lower Cambrian rocks, as well as the previously reported Middle Cambrian, are well exposed. Several weeks in 1943 and 1944 were devoted to investigations of these rocks and making collections of fossils.

The collection of fossils obtained from the vicinity of Caborca is a very fine one and consists of numerous kinds of animals. In the interest of accuracy and to lend utmost authority to this report on the Mexican Cambrian it seemed best to invite specialists to describe the

various groups. Accordingly, Dr. J. Harlan Johnson, Colorado School of Mines, Golden, Colo., was invited to describe the peculiar algae known as *Girvanella;* Dr. Vladimir J. Okulitch, authority on the Pleospongia, contributed the chapter on these interesting and bizarre animals; G. A. Cooper, who has long been interested in the Brachiopoda, prepared the discussion of this group; Dr. Alexander Stoyanow, University of Arizona, who was the first to announce the discovery of Cambrian in this portion of Mexico, consented to describe the specimens that were first found; and Dr. Christina Lochman described the trilobites, which form the largest part of the fauna. She also described some of the peculiar and problematical forms which lend so much fascination to the Cambrian.

Seven areas containing Cambrian rocks were located in the vicinity of Caborca: (1) Cañedo Hill, on the east side of Caborca and on the south bank of the Magdalena River; (2) Prieto Hill, a small hill about 1½ miles southwest of the village; (3) Difuntos Hills, a group of small hills about 14 miles northwest of Caborca; (4) Buelna Hills, two small hills just south of the railroad about 9 miles northwest of Caborca; (5) Lista Blanca, 5-6 miles west-southwest of Caborca; (6) Arrojos Hills, about 12 miles west-southwest of Caborca; and (7) Proveedora Hills, on the north side of Puerto Blanco, 6-7 miles west of Caborca. Inasmuch as the Proveedora Hills include an unbroken section about 1 mile long, it seems best to describe it first and thus establish the units into which the Mexican Cambrian is divided. After the description of this section the sequences at other localities will be explained.

LOCALITIES

Proveedora Hills (Cerros de la Proveedora) (Locality 801)

The Cerros de la Proveedora are a roughly longitudinally oval group of hills trending northward and located about 6 miles west of Caborca on the north side of the road through the gap known as Puerto Blanco (text figs. 1, 2, 5). The main mass of the hills consists of two elongated ridges separated by a deep valley interrupted in its middle by a low saddle. These hills lie on the north side of a large granitic mass which has metamorphosed their southern edge and, in one place at least, intruded the Cambrian beds. The southern end of the hills is broken into several knobs of various sizes, mostly composed of white marble, clearly an alteration product of contact metamorphism.

The Proveedora Hills are composed wholly of Cambrian sediments but neither the stratigraphic top nor bottom of the sequence is known.

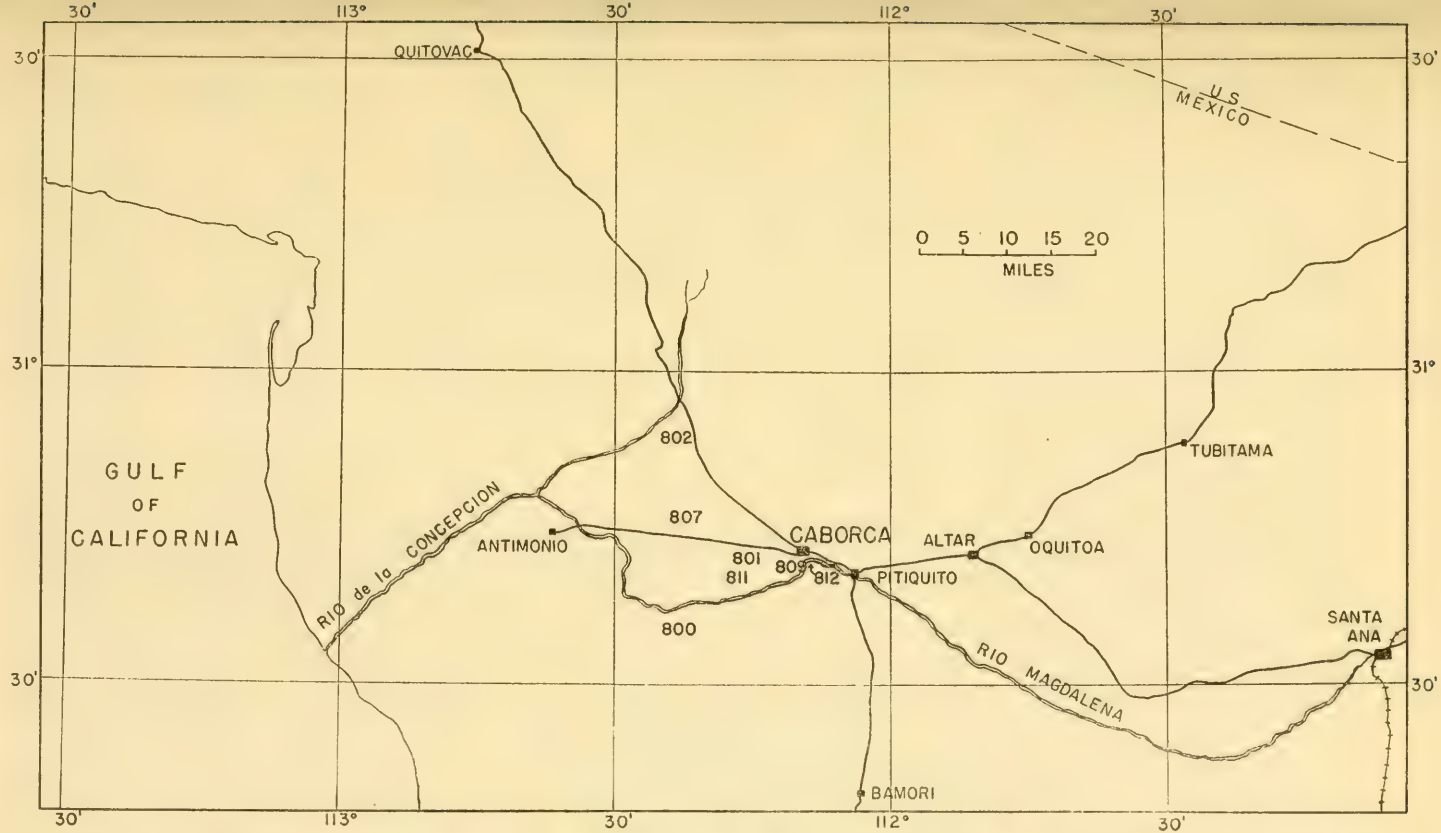


FIG. 1.—Map of region about Caborca showing location of Cambrian collecting localities. 800, North end Arrojos Hills; 801, Proveedora Hills; 802, Difuntos Hills; 807, Buelna Hills; 809, Prieto Hill; 811, Lista Blanca; 812, Cañedo Hill.

The lowest sediments appear in the small knob on the west end of the hills. The strike of the sediments is a few degrees west of north (N. 7° W.) and the dip is quite variable, but all the angles measured are steep, generally greater than 60°. The dip in the west ridge and the hills to the west is generally to the east. Dips on the west side of the saddle between the two main ridges are to the west, but on the opposite side of the saddle they are to the east. Strong lithological differences in parts of the hills permit division into six formations, in ascending order: Puerto Blanco, Proveedora, Buelna, Cerro Prieto, Arrojos, and Tren formations (text figs. 4, 5). The fossil content of the first three indicates a Lower Cambrian age. The Cerro Prieto formation has not been dated, but the Arrojos and Tren formations belong in the Middle Cambrian.

Puerto Blanco formation.—This formation occupies the low ridge and knob at the west end of the hills. No basal contact is known at this place and none was seen elsewhere; consequently, the full thickness of the Puerto Blanco formation cannot be stated. The base of the section consists of about 120 feet of greenish slaty rock followed by 20 feet of limestone with a foot of sandstone at the base. In these beds *Hyolithes, Olenellus, and Lingulella* were found. Reddish shale and calcareous sandstone are followed by platy limestone containing fragmentary olenellid trilobites. The formation is terminated by quartzites, slates, and marble. The formation is 961 feet thick. The type section is the west end of the Proveedora Hills.

The Puerto Blanco formation contains many fossils of a few kinds, but the rock is usually too indurated to allow the specimens to be broken out. Nevertheless, by searching for pieces softened by weathering, or ones leached of lime, excellent specimens may be obtained. The most significant fossils taken are the brachiopod *Obolella* and olenellid trilobites. The brachiopod is characteristic of the earliest zone of Cambrian life.

Proveedora formation.—This formation consists of 732 feet of thick, white indurated quartzite and dark-gray slaty shale or greenish slaty shale. The quartzite often forms low ridges. Fossils are rare in the formation, but unidentifiable linguloid brachiopods and olenellid fragments appear on some of the weathered surfaces. The type section is in the Proveedora Hills.

Buelna formation.—This formation is composed chiefly of limestone. Approximately the lower half is separated from the upper half by a prominent ledge about 23 feet thick. The lower half is composed of thin-bedded bluish-gray limestone. The upper half consists of platy brownish limestone, *Girvanella* beds, thin-bedded gray limestone,

FIG. 2.—Map of Proveedora Hills showing formational boundaries and collecting localities 801-b, c, h-k, ka, l-o, q, x, y. ЄPB = Puerto Blanco; ЄP = Proveedora; ЄB = Buelna; ЄCP = Cerro Prieto; ЄA = Arrojos; ЄT = Tren. Surveyed and drawn by Ing. A. R. V. Arellano.

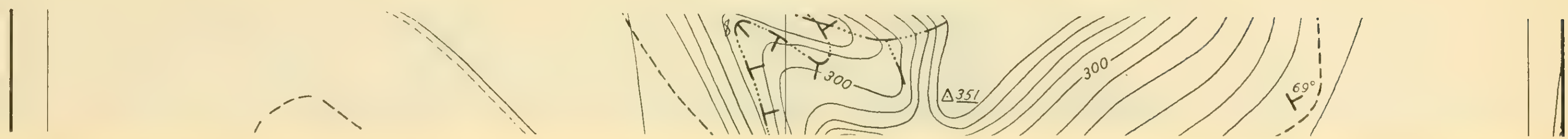


FIG. 2.—Map of Proveedora Hills showing formational boundaries and collecting localities 801-b, c, h-k, ka, l-o, q, x, y. €PB = Puerto Blanco; €P = Proveedora; €B = Buelna; €CP = Cerro Prieto; €A = Arrojos; €T = Tren. Surveyed and drawn by Ing. A. R. V. Arellano.

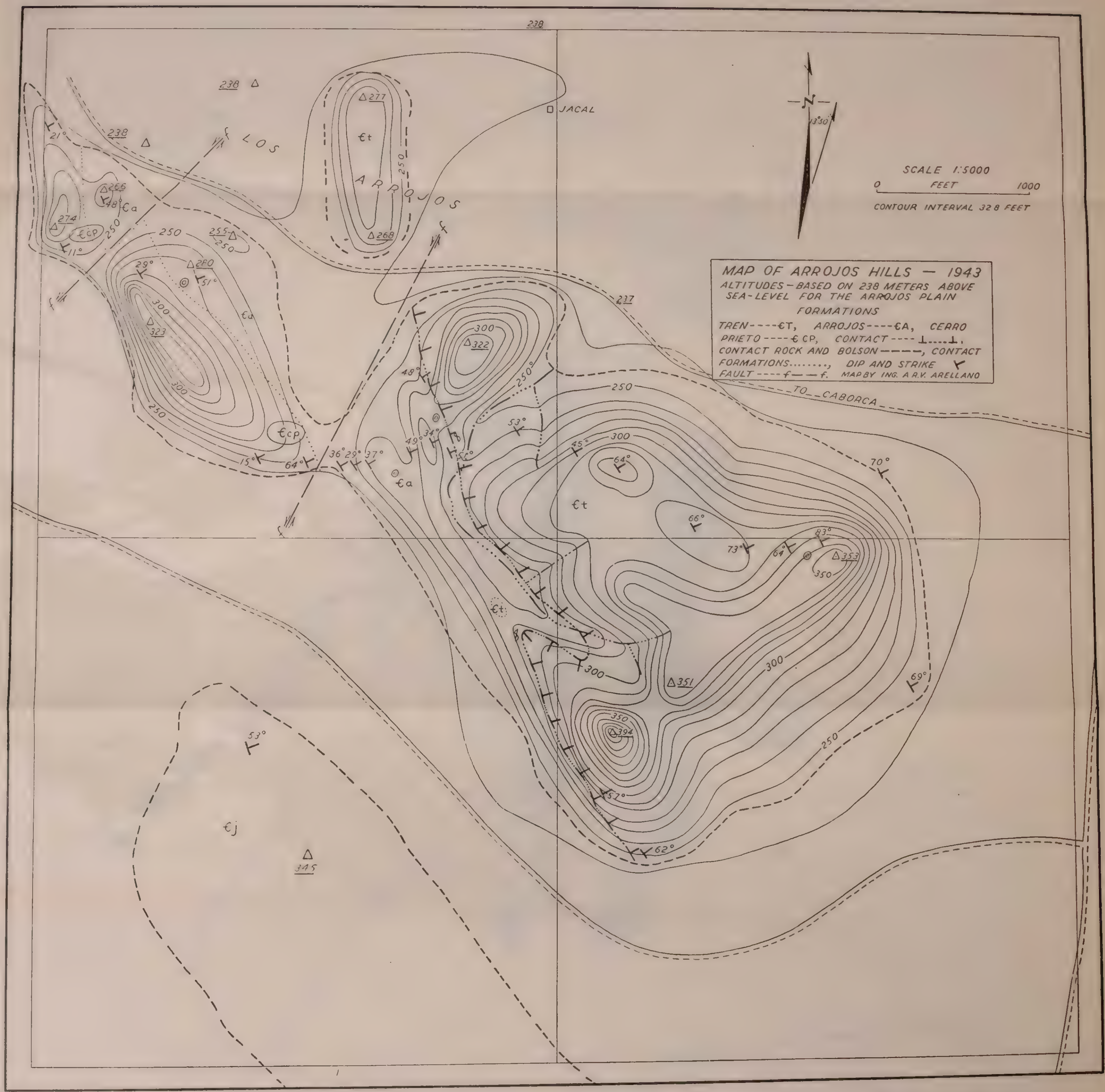


Fig. 3.—Map of Arrojos Hills showing formational boundaries and collecting localities 800-a, c-h. Surveyed by Ing. A. R. V. Arellano.

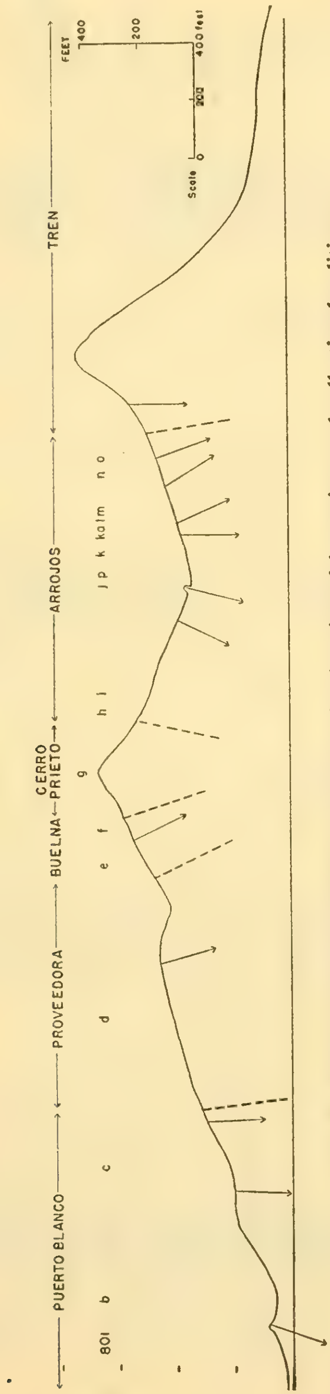
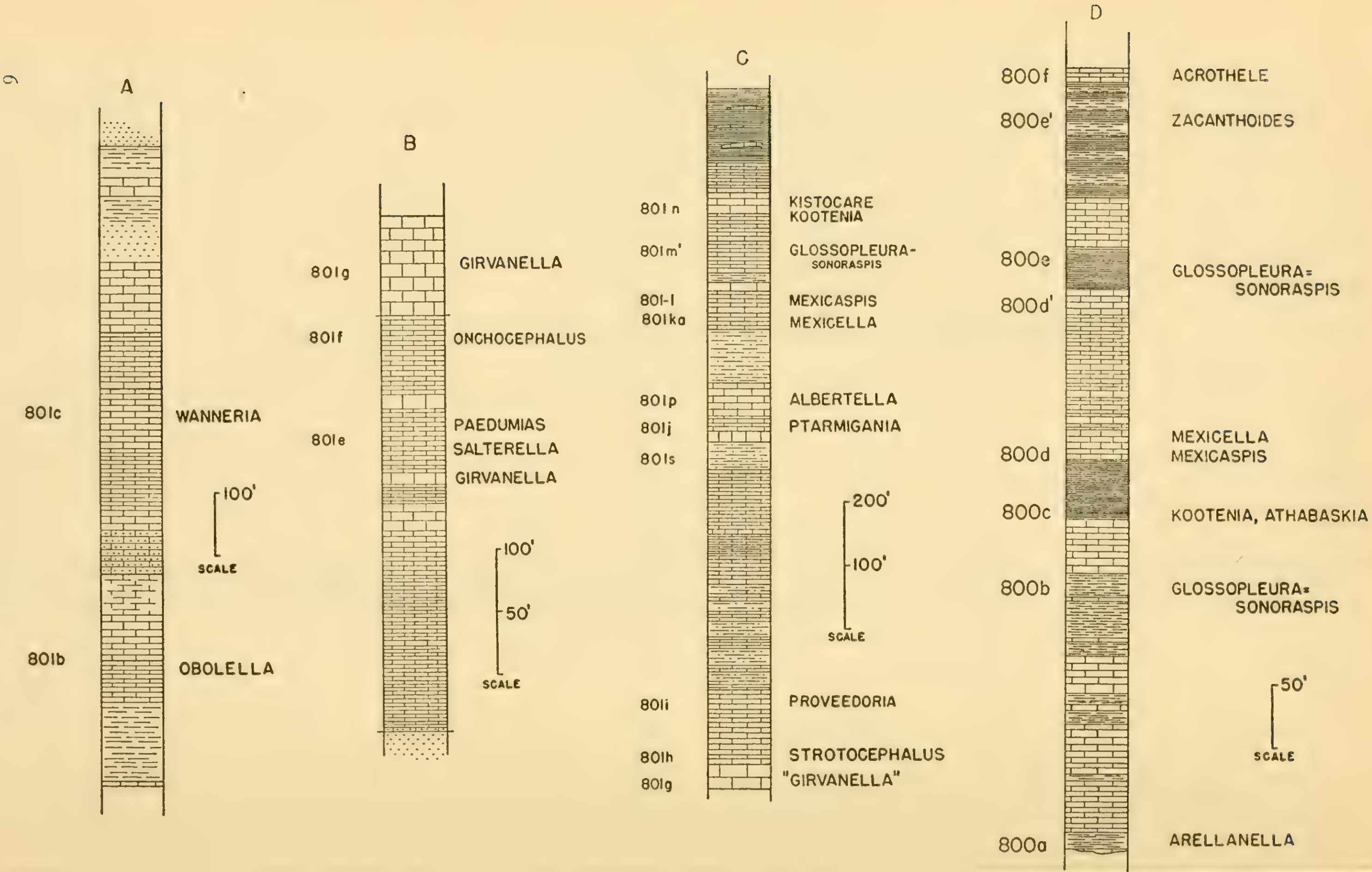


Fig. 4.—Profile across Proveedora Hills showing location of formations and collecting localities.


A
801c
WANNERIA
100'
SCALE
801b
OBOLELLA
B
801g
GIRVANELLA
801f
ONCHOCEPHALUS
801e
PAEDUMIAS
SALTERELLA
GIRVANELLA
100'
50'
SCALE
C
801n
KISTOCARE
KOOTENIA
801m'
GLOSSOPLEURA-
SONORASPIS
801-l
801ka
MEXICASPIS
MEXICELLA
801p
801j
801s
ALBERTELLA
PTARMIGANIA
200'
100'
SCALE
801i
PROVEEDORIA
801h
801g
STROTOCEPHALUS
"GIRVANELLA"
D
800f
ACROTHELE
800e'
ZACANTHOIDES
800e
GLOSSOPLEURA=
SONORASPIS
800d'
800d
MEXICELLA
MEXICASPIS
800c
KOOTENIA, ATHABASKIA
800b
GLOSSOPLEURA=
SONORASPIS
50'
SCALE
800a
ARELLANELLA

oolitic limestone, and brecciated limestone followed by platy limestone. Thin layers made up of the crowded shells of the peculiar cephalopod *Salterella* appear in the lower part of the section. In this part, too, olenellid trilobites are frequent. In the upper part of the section several characteristic trilobites, *Onchocephalus, Antagmus,* and *Bonnia* were collected. The first two define the zone that bears their names and that has a wide distribution in the United States. The Buelna formation measures 331 to 398 feet.

The presence of olenellid trilobites dates this formation as part of the Lower Cambrian sequence, but *Onchocephalus* and *Antagmus* prove the formation to be near the top of the Lower Cambrian.

Cerro Prieto formation.—This formation is characterized by its massive and resistant character. It forms the high ridge on the west side of the valley dividing the two main ridges of the Proveedora Hills. This limestone is dark gray to black in color and is without bedding. It often contains wavy banding, possibly produced by flowage. Irregular white calcite veins are another distinctive feature. It also contains some light-colored marble where it occurs near intrusions. The most distinctive character of all, however, is the abundance of dark spherical objects often with indistinct concentric layering. These suggest the probable alga *Girvanella* and occur in countless numbers. This formation is 329 feet thick.

Fossils other than the *Girvanella* mentioned above were not seen in this formation, although a diligent search was made for them. It is thus impossible to date this limestone. It overlies *Olenellus*-bearing Buelna limestone and underlies the Arrojos formation, which contains many Middle Cambrian fossils. Although no diagnostic fossil was found, the formation is here placed arbitrarily in the Lower Cambrian. The type section is in Prieto Hill about 1½ miles southwest of Caborca (locality 809).

Arrojos formation.—This formation is characterized by the thin-bedded nature of most of its different sediments. It makes a zone of weakness between the two main ridges of the Proveedora Hills. The lowermost 300 feet consists of thin platy limestone, sandy and limy shale, and shale. Fossils are not common, but a few were found in the thin limestones. This sequence is succeeded by 43 feet of olive-gray, smooth-weathering limestone having a blue to blue-gray color on fractured surface. Some of the layers weather to a bright orange-yellow or a light-brown color, making conspicuous patches or bands. The next 138 feet are composed mostly of shale and thin-bedded limestone. The upper 40 feet of this division is in red sandy shale, under-

lain by a conspicuous yellow band. Under this sequence is mostly thin-bedded limestone.

Following the preceding 40 feet is a ledge about 18 feet thick which makes an excellent datum. It forms a high wall on the west side of the saddle between the two hills (pl. 1, fig. 2; text fig. 4).

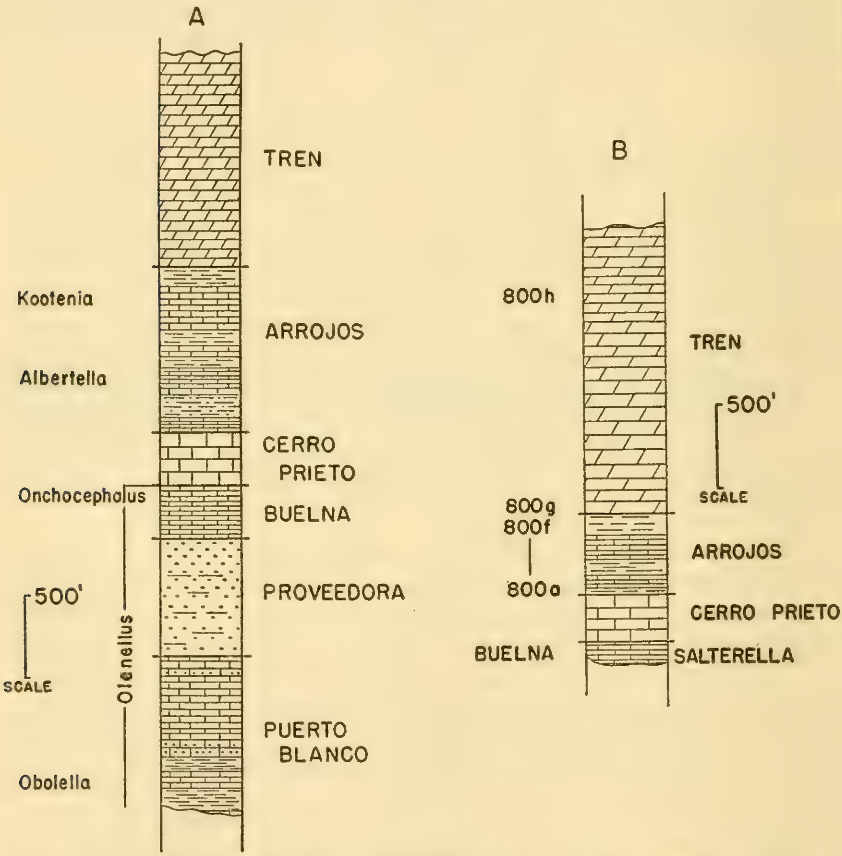


Fig. 6.—Columnar sections of Proveedora Hills (A) and Arrojos Hills (B) showing formations. Differences in thickness between the sections are clearly shown.

The succeeding division, 159 feet thick, abounds in fossils characteristic of the Middle Cambrian. In contact with the thick ledge is a cobbly, yellow-weathering limestone containing *Ptarmigania.* Above this, slightly higher in the section, are thin platy limestones containing *Albertella, Mexicaspis* and *Mexicella,* and *Glossopleura.*

The next succeeding 249 feet are composed of thin-bedded limestone

with some heavier-bedded layers. Many of the layers abound in *Girvanella* of various sizes. Near the top of this division *Kootenia* is common in a limestone that weathers bright orange yellow. The top of the section consists of 105 feet of dark shale containing some limestone layers. This shale is mostly covered by talus from the overlying Tren formation.

The Arrojos formation totals about 1,018 feet in thickness. It contains several zones of characteristic Middle Cambrian fossils, consequently no difficulty was experienced in dating this formation, but its correlation with other sections near Caborca is difficult. Although the fossils in the lower part are regarded as of Middle Cambrian age, it must be reported that *Salterella*, normally a Lower Cambrian fossil, was found on the west slope of the valley between the two main ridges. This specimen was not found in place, but it could not have been derived from any other part of the hills by natural means. This can be determined to anyone's satisfaction by examining the panorama of the Proveedora Hills (text fig. 4). It will be noted that the Cerro Prieto formation forms the crest of the highest ridge and effectively separates the *Salterella*-bearing Buelna formation from the Arrojos formation. Consequently, the *Salterella* must have been derived from the lower Arrojos limestone. The type section of the formation is at the north end of the Arrojos Hills, 12 miles west-southwest of Caborca.

Tren formation.—Overlying the thin-bedded and often shaly Arrojos formation occur 1,608 feet of dark dolomite, which forms the easternmost and highest ridge of the Proveedora Hills. This is named Tren formation from a similar mass in the Arrojos Hills. The formation is composed almost wholly of dark dolomite with some dark limestone beds and occasional layers of metamorphosed dolomite in the form of finely granular marble. No fossils were found in the section. The type of dolomite is not the kind to produce any fossils. In the Arrojos Hills this formation yielded three trilobite specimens which enabled it to be dated as Middle Cambrian in age. The type section of the formation is in the high hill on the east side of the north end of the Arrojos Hills. In the Proveedora Hills, as in the Arrojos Hills, this formation forms the top of the sequence, but the stratigraphic top of the Tren formation is unknown.

Cañedo Hill (Cerro de Cañedo) (Locality 812)

This is a small hill located on the south side of the Magdalena River on the east side of Caborca. The hill forms a monocline with steep dip (30° to 50°) to the south and lies at the north end of a long

chain of igneous hills. It thus has essentially the same relation to an igneous body as the Proveedora Hills, but in the case of the Cañedo Hill the metamorphism has greatly affected the entire mass. The shales, limestones, and sandstones are strongly metamorphosed but not enough to destroy completely the evidences of sedimentation and occasional fossils. Near the top of the hill *Salterella* was found, thus well establishing the age of the hill as Lower Cambrian.

On the north side of the road to Pitiquito, which goes east through the pass between Cañedo Hill and the igneous mass to the south, limestone and shale were examined which are lithologically similar to the Cambrian on the west side of the Proveedora Hills. Some of the limestone shows faint shadows of *Girvanella* although the rock is completely altered. In a thin marbleized limestone trilobite fragments and *Obolella* were identified. The latter dates the sequence as Lower Cambrian and correlates it with the lowest part of the Puerto Blanco formation of the Proveedora Hills.

Prieto Hill (Cerro Prieto) (Locality 809)

Prieto Hill, or Cerro Prieto, is a small, low, rounded eminence located about 1½ miles southwest of Caborca (text fig. 7, A). On the north side of the hill lies a small knob composed of quartzite which forms the lowest of the exposed sequence. The quartzite is 145 feet thick, hard, sugary, vitreous, heavy-bedded, often showing the bedding as black lines or bands. The dip is to the southwest and varies from 11° to 18°. No fossils were seen in it.

The north front of Prieto Hill consists of a steep slope surmounted by a scarp face of massive limestone. The lower part of the slope is made up of thin to moderately heavy-bedded limestone, generally gray to blue-gray in color. In yellowish shale at the base of the hill thin limestones are crowded with *Salterella*. Higher in the section much of the rock is covered, but the slope is strewn with cobbles abounding in fossils. About 60 feet below the bold cliff, limestone in place yielded numerous trilobites.

The fossils taken from this sequence include *Onchocephalus* and olenellid trilobites. These clearly indicate correlation with the Buelna formation of the Proveedora section. The formation measures 275 feet thick.

An interesting feature of these limestones is the lime sand in parts of the section. The rock grains strongly resemble oolites, but when the individual spheres are broken they do not show the characteristic concentric layers of oolites. The structure revealed is that of crystalline

calcite. The spheres are evidently grains of clear calcite rounded by wave or current action, forming a calcite "sand."

The main cliff forming the scarp of the hill and the long dip slope to the south are composed of dark-gray to black massive limestone. The upper surface near the brow of the hill shows numerous large

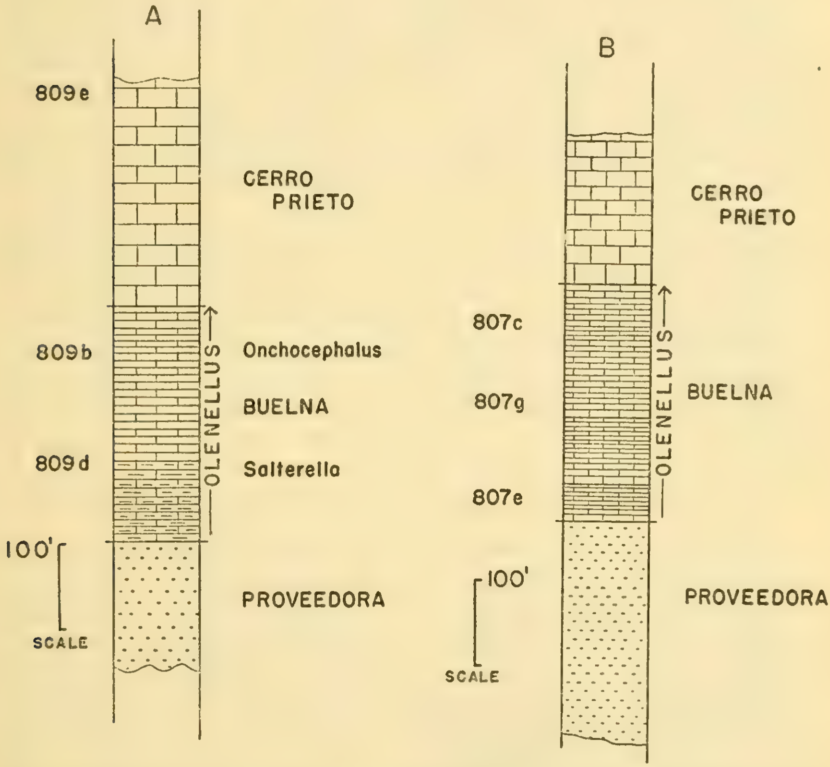


FIG. 7.—Comparison of sections in Prieto Hill (A) and Buelna Hills (B) showing close similarity of the sections.

Girvanella on the weathered surfaces. These bodies are of two kinds: one is black and shows crude concentric structure; the other is light gray. This limestone is thus the Cerro Prieto formation, the same massive rock that lies between the Buelna and Arrojos formations in the Proveedora Hills. The capping ledge of Prieto Hill is the locality from which this formation is named. Here it is 267 feet thick. No trace of the Arrojos formation was seen at this place.

Difuntos Hills (Cerros de los Difuntos) (Locality 802)

This is a small group of hills about 14 miles northwest of Caborca. The easternmost hill consists of thin-bedded yellow to pinkish limestone with some massive reefy lenses containing small *Girvanella,* particularly at the south end of the hill. Fossils are rare and include pleosponges and olenellid trilobites. These were found loose, but no question as to their place of origin can be raised. The olenellids date the formation as Buelna formation. The occurrence of pleosponges indicates reefy limestone as a facies of this formation. The Buelna formation is overlain by the Cerro Prieto formation.

On the northeast side of the largest hill, thin-bedded fossiliferous limestones occur in the lower part. Thirty to thirty-five feet vertically above the valley floor *Albertella* and *Mexicella* are abundant in brownish platy limestone. One hundred and ten feet above the plain *Glossopleura* is abundant. At the top of the thin-bedded limestone an 18-inch layer of reddish oolitic limestone contains abundant *Pachyaspis.* These beds are correlated with those in the saddle between the two ridges of the Proveedora Hills (localities 801ka-L). The main mass of the western Difuntos Hills is made up of the Tren dolomite formation.

Buelna Hills (Cerros de Buelna) (Locality 807)

These are two small hills located just south of the railroad about 9 miles northwest of Caborca (text fig. 7, B). The larger hill is here called West Buelna; the smaller is the East Buelna. In the West Buelna an excellent section of the Proveedora quartzite formation appears in the lower part of the section, estimated at 300 feet in thickness. It is here notable for the occurrence low in the section of extensive layers containing vertical tubes of *Scolithus* (see pl. 11). Blocks nearly 2 feet thick marked by the carbon-filled tubes occur in profusion.

The Proveedora quartzite is overlain by the Buelna formation, about 280 feet of thin-bedded limestone. Just above the quartzite, olenellid trilobites and *Salterella* are abundant in dark-gray limestone. Above this occur massive light-gray limestones with much calcite veining. This is followed by yellowish limestone with *Salterella, Onchocephalus,* and *Paedeumias. Girvanella* is abundant in many parts of the sequence. This is the type section of the Buelna formation.

The top of the section is composed of massive dark-gray limestone containing many small calcite veins. This is the Cerro Prieto formation. The Buelna Hills thus duplicate the sequence seen in Prieto Hill southwest of Caborca (text fig. 7).

Lista Blanca (Locality 811)

Lista Blanca consists of a series of small elongate hills on the south side of the Magdalena River about 5 to 6 miles west-southwest of Caborca and occurs at the north end of a chain of igneous rocks extending for some distance to the south. Actually it occupies a position between two igneous masses; the one on the north is the igneous block on the south side of the Proveedora Hills. Lista Blanca therefore appears to be a block caught in igneous masses on the north and south. Its situation is similar to that of the Proveedora Hills but, as it occupies a position between the two igneous blocks, it is considerably more metamorphosed than the rocks of the Proveedora Hills. For this reason fossils are extremely difficult to find and are poor when found. Nevertheless, the evidence accumulated makes it clear that the rocks of Lista Blanca belong to the Middle Cambrian.

Lithologically the rock of Lista Blanca is a metamorphosed dolomite, some of which is altered to white marble. The latter is especially prominent at the east end of the hills. In a bed of shale about 20 feet thick three specimens definitely recognizable as trilobites were found. These are of Middle Cambrian types, although their precise identification is not possible. Lithologically the Lista Blanca sequence strongly suggests the Tren formation of the Proveedora Hills.

Arrojos Hills (Cerros de los Arrojos) (Locality 800)

The Arrojos Hills are located on the south side of the Magdalena River about 12 miles west-southwest of Caborca. Like the Proveedora Hills and Lista Blanca these hills lie at the north end of a long igneous chain and were affected by the baking action of the intrusion. The northernmost of the Arrojos Hills are not greatly metamorphosed, but when they are followed to the south along the strike of the Cerro Prieto formation, which forms a prominent part of them, the black limestone alters to white marble and the quartzites are baked and considerably altered.

The longest and best section is at the north end of the hills. The lowest beds exposed are in the highest hills. On the west side of this hill a short section of the Proveedora quartzite is followed by the Buelna formation with trilobites and *Salterella.* The Cerro Prieto formation is prominent and forms the main bulk of the westernmost chain of hills. As elsewhere, it is dark gray to black with calcite veins and black *Girvanella.* Traced to the south along the hills the Cerro Prieto formation becomes more and more altered as one approaches the igneous body south of the Cambrian hills. On the north side of the

pass between the Cerro Prieto and the igneous body the limestone is altered to marble. On the south side of the pass, baked Proveedora quartzite overlies the igneous rock. Even at the north end of the hills some flow structure is visible. The thickness of the Cerro Prieto formation as measured was about 300 feet.

The Arrojos formation is well exhibited at this place. It is the type section of the formation selected by Dr. Alexander Stoyanow, who named it. It was measured as 620 feet thick, but the accuracy of the figure may well be questioned.

The dip to the east in the lower part of the section is about 20°, but it varies up to 50°. Furthermore, a small fault on the northwest side of the hills makes it impossible to measure the sequence in a continuous section. The lowest beds are greenish, fine-grained slaty shales with thin limestone lenses containing numerous trilobites and brachiopods. Then follows platy limestone, a little red shale, and a fine-grained limestone with conchoidal fracture that weathers orange-yellow. These beds are followed by shales, salmon-weathering limestone and more greenish micaceous slaty shale containing thin limestone layers. The shales often weather red. This shale sequence contains the lowest zone of *Glossopleura-Sonoraspis.* The shale sequence is capped by a thick bed of banded limestone that forms a ridge of dark-gray to black massive limestone along the brow of the hill. The top beds are oolitic.

The heavy ledge of limestone is succeeded by thin-bedded dark shale containing lenses of limestone. At the base the lenses abound in fossils, particularly the brachiopod *Diraphora,* the sponge *Chancelloria,* and the trilobite *Kootenia.* The dark shales are succeeded by a long sequence of thin-bedded dark-gray limestone containing the trilobite *Mexicaspis* at the top.

The *Mexicaspis* beds are followed by another band of slaty shale containing the second *Glossopleura-Sonoraspis* zone. The shale is dark, splintery, and grades into limestone along its strike. Banded limestone, thin-bedded, oolitic, and with abundance of *Girvanella,* follows the second *Glossopleura-Sonoraspis* zone.

The longest sequence of shale, green to black, crumbly and fossiliferous, succeeds the *Girvanella* beds. This shale contains a variety of trilobites but none of them are very well preserved. Of considerable interest at this level is the occurrence of the trilobite *Zacanthoides.*

The Arrojos sequence at this place is capped by a band of cobbly yellow-weathering limestone abounding in *Acrothele,* a typical Middle Cambrian brachiopod. The cobbly beds make a striking contrast to the overlying Tren formation.

The Tren formation is a complicated sequence of limestones and dolomites, some of the beds in places altered to marble. The thickness of the Tren formation as measured was 1,744 feet. As would be expected in a dolomite sequence, especially a considerably altered one, fossils are absent or exceedingly rare. Nevertheless, in the gray granular limestone at the base of the section fossils are fairly common. These are mostly brachiopods, particularly the small conical *Pegmatreta.*

In spite of its unfavorable lithology, a mottled limestone 1,320 feet above the base produced three poorly preserved trilobite heads. Although these cannot be identified more closely than their genus, they show beyond question that the entire sequence of the Tren formation is of Middle Cambrian age.

ADDITIONAL LOCALITIES OF CAMBRIAN ROCKS

In addition to the localities listed above, a few small isolated hills show parts of the sequence not represented in the sections described or parts not easily located or identified with any portion of the measured sections. These are located west and northwest of the west end of the Proveedora Hills.

Locality 801q.—This may be reached by traveling 0.7 mile (3,468 feet) N. 23° W. of the Proveedora Hills. Here is a small knoll of limestone having the strike N. 18° W. and dip 17° to 20° to the southwest. The lowest bed consists of 15 feet of heavy-bedded gray limestone. This is followed by a 10-foot covered interval. The next bed is gray massive limestone showing little bedding. Then follows 5 feet of limestone in beds 6 to 8 inches in thickness containing oolites and fossils: *Hyolithes* and *Salterella.* This is followed by thin-bedded sandy limestone, some of it pink in color. On this layer occur two reef masses of pink limestone having thin, wavy bedding and containing pleosponges. These masses are about 20 feet thick. Overlying them is massive gray limestone with numerous calcite veins.

Locality 801x.—About 0.6 mile (3,225 feet) N. 60° W. from the knob just described is situated another small hill composed of massive hard limestone much fractured and with the seams filled by calcite. No fossils were seen in this knob, but its situation in relation to the previous one and those described below suggests that it, too, belongs to the Lower Cambrian.

Locality 801y.—North of this knob occurs another pleosponge reef having a diameter of about 75 feet. The beds dip 36° to the southwest. This reef lies about 0.8 mile N. 48° W. of the first reef (801q).

Locality 807j.—About 0.7 mile (3,750 feet) N. 55° W. of the hill of massive fractured limestone (3,750 yards N. 48° W. of the west end of the Proveedora Hills) occurs a small hill structurally a syncline of sandstone. The lowest bed consists of about 11 feet of massive dark quartzite. This is followed by 11 feet of calcareous dark-brown sandstone. On top of this bed 5 feet of fossiliferous quartzite was measured containing chiefly olenellid trilobite debris. The section is capped by massive quartzite, about 18 feet thick with fossils at the base. This sequence suggests relationship to the Proveedora quartzite, but it is not now possible to be certain of such an assignment.

Locality 801z.—Another hill lies to the southwest of the quartzite hill. This is located S. 75° W. about 4,438 feet. It is a long, low hill composed of limestone beds striking N. 22° W. and dipping 25° to the northeast. About 160 feet of thin-bedded alternating dark and gray limestone is exposed. This is much brecciated at the south end of the exposure. On the north it is bordered by basaltic rock, and a low hill of the same-appearing material lies to the south. The limestone suggests the Tren formation, but no further proof or evidence is available than appearance.

SUMMARY OF CAMBRIAN STRATIGRAPHY AND CORRELATION BETWEEN LOCALITIES

With present knowledge it is easier to understand the correlation between localities of the Lower Cambrian in the Caborca region than with the overlying beds (text fig. 5). The Puerto Blanco formation is known only at the west end of the Proveedora Hills and in the highly altered mass at Cañedo Hill. At the former place, however, a complete section is not present because the base has not been found. No Cambrian beds were seen in contact with any of the Pre-Cambrian rocks on the east side of Caborca or in the vicinity of Pitiquito where pre-Cambrian beds are well displayed. It is not known, moreover, to what part of the section the pleosponge reefs west of the Proveedora Hills are to be assigned. They are definitely Lower Cambrian, but may lie under the Puerto Blanco sequence.

The overlying Proveedora formation occurs in several sections: Prieto Hill, Buelna Hills, Proveedora Hills, sparingly at Arrojos Hills. The quartzite hill west of the Proveedora Hills probably belongs to the Proveedora quartzite, but this is not a certainty.

The Buelna formation is well exposed in several hills, and little difficulty attends its recognition. Excellent exposures occur in Prieto Hill, the Proveedora and Buelna Hills. A less extensive exposure is known in the Arrojos Hills. In the Difuntos Hills this formation

contains pleosponges. This is the only locality at which these fossils were found in a sequence.

The Cerro Prieto formation has the same distribution as the Buelna formation, but its exposures are very extensive in the Proveedora and Arrojos Hills. The occurrence at Prieto Hill is of considerable interest because of the fine development of *Girvanella* on the surface. This hill was previously identified as of Pennsylvanian age and a Caborca series (Gamusa) of beds was established to accommodate these supposed Upper Paleozoic rocks. It is quite probable that the large *Girvanella* of the Cerro Prieto formation were mistaken for Pennsylvanian *Chaetetes* on which the dating was based. The abundance of algae in the Cerro Prieto formation leads to the belief that it may represent a great Cambrian algal reef.

The Arrojos formation is known from two very fine, thick sequences and a shorter section (text fig. 3). Although the bulk of the fossils described in this report came from the Arrojos formation in the Arrojos Hills and Proveedora Hills, the sequences are not well enough known to establish a satisfactory correlation. This is not true of the Arrojos formation exposed in the Difuntos Hills. This short section belongs to the *Mexicella-Mexicaspis-Albertella* zone. This is the same horizon as that located on the east side of the saddle in the Proveedora Hills (locality 801ka-L).

One zone of the Arrojos section seems to correlate with one in the Proveedora sequence. This is the *Kootenia* zone which in both sections contains similar fossils although the lithologies are not alike. Correlation of these two zones, however, does not lead to any other agreement between the two sections. In the Proveedora sequence *Mexicella* occurs under the *Kootenia* zone, whereas in the Arrojos section *Mexicella* is present above *Kootenia*. No structural complications were detected while making the Arrojos section, although they may have escaped notice. It is possible that a considerable facies difference occurs between the two sections.

That a facies difference exists between the two sections is suggested by a comparison of the lithologies. In the Proveedora sequence limestone predominates except in the upper 105 feet from which few fossils were taken because of heavy cover. In the Arrojos section, on the other hand, several important shale beds appear and in each of these fossils characteristic of shales were seen. This is especially true of *Glossopleura-Sonoraspis* which occurs in several parts of the section. *Kootenia* has a long range in the Middle Cambrian outside of Mexico and it is therefore possible that the two Mexican occurrences of this trilobite cannot be correlated. The problem cannot be settled

in this discussion and must await solution in further collecting and reference to other sections.

The Tren formation is known in the Difuntos, Arrojos, and Proveedora Hills. In each place it is chiefly a dolomite which yields few fossils or none at all.

LOCALITIES AND FAUNAL LISTS

Locality 800. North end of the Arrojos Hills, 12 miles west-southwest of Caborca, Sonora.

800a. Arrojos formation, basal shale, on east side of northwesternmost small hill.

Micromitra species.
Pegmatreta rara Cooper.
Acrothele species.
Dictyonina species.
Arellanella caborcana Lochman.
A. sonora Lochman.
Alokistocare cf. *A. modestum* Lochman.
Kistocare tontoensis (Resser).
Chancelloria eros Walcott.
Hyolithes sonora, Lochman.

800b. Arrojos formation, first *Glossopleura-Sonoraspis* bed, under heavy ledge of limestone, west face of largest hill.

Arellanella aff. *A. sonora* Lochman.
Glossopleura-Sonoraspis species.

800c and c′. Arrojos formation, *Caborcella* bed, base of dark shale about 260 feet above base of section, northwest side of largest hill.

Diraphora arrojosensis Cooper.
Athabaskia bela (Walcott).
Caborcella arrojosensis Lochman.
Kistocare corbini Lochman.
Alokistocarella mexicana Lochman.
Kootenia exilaxata Deiss.
Hyolithes sonora Lochman.
Chancelloria eros Walcott.
Helcionella species undetermined.

800d. Arrojos formation, *Mexicaspis* bed, about 312 feet above base of section, northwest side of largest hill.

Mexicella mexicana Lochman.
Mexicaspis stenopyge Lochman.
Problematicum III.

800e. Arrojos formation, upper *Glossopleura-Sonoraspis* bed, northwest side of largest hill.

Glossopleura-Sonoraspis species.
Inglefieldia imperfecta Lochman.

800e′. Arrojos formation, 15-20 feet below top of uppermost shales with *Zacanthoides,* saddle at north end of largest hill just west of

northernmost knob, just northwest of elbow of canyon in largest hill.

Glossopleura-Sonoraspis species.
Zacanthoides aff. *Z. holopygus* Resser.
Inglefieldia imperfecta Lochman.

800f. Arrojos formation, *Acrothele* beds, uppermost 8 feet of yellow-weathering cobbly beds at top of Arrojos formation. Saddle on west-side knob at north end of largest hill.

Dictyonina minutipuncta Cooper.
Acrothele concava Cooper.
Glossopleura-Sonoraspis species.
Inglefieldia imperfecta Lochman.

800g. Tren formation, basal limy beds, saddle on southwest-end knob at north end of largest hill

Dictyonina species.
Acrothele species.
Pegmatreta arellanoi Cooper
Athabaskia minor Resser.
cf. *Inglefieldia imperfecta* Lochman.

800h. Tren dolomite, 1,320 feet above the base, near the top of the northeast-southwest ridge on south side of largest hill.

Parehmania species undetermined.
Genus and species undetermined 3.

Locality 801. Proveedora Hills on north side of Puerto Blanco, 6-7 miles west of Caborca.

801b. Puerto Blanco formation, *Obolella* beds, west end, Proveedora Hills.

Obolella mexicana Cooper.
Lingulella proveedorensis Cooper.
Olenellus species undetermined.
Salterella species.
Hyolithes aff. *H. princeps* Billings.
Problematica I, II.

801c. Puerto Blanco formation, 590 feet above base of section, west side, Proveedora Hills.

Wanneria mexicana prima Lochman.
Zacanthoides aff. *Z. holopygus* Resser.

801d. Proveedora formation.

Linguella species.
Olenellid trilobite fragments.

801e. Buelna formation, near center, Proveedora Hills.

Salterella mexicana Lochman.
Paedeumias puertoblancoensis Lochman.

801f. Buelna formation, west central part, Proveedora Hills.

Paterina species.
Paedeumias puertoblancoensis Lochman.
Onchocephalus buelnaensis Lochman.
O. mexicanus Lochman.

801g. Cerro Prieto limestone.

Girvanella? species.

801h. Base of Arrojos formation, center of the Proveedora Hills.
Nisusia species.
Strotocephalus arrojosensis Lochman.
Kochaspis? species undetermined.
Hyolithes species.
Genus and species undetermined 2.

801i. Arrojos formation, 100 feet above base, center, Proveedora Hills.
Albertella proveedora Lochman.
Proveedoria starquistae Lochman.
Kochaspis? species undetermined.

801j. Arrojos formation, cobbly beds with *Ptarmigania,* just above ledge on west side of saddle.
Ptarmigania bispinosa Lochman.
Mexicella mexicana Lochman.

801k. Arrojos formation, *Albertella* beds about 625 feet above base, saddle between ridges.
Mexicella mexicana Lochman.
Albertella proveedora Lochman.
Kochaspis cooperi Lochman.

801ka. Arrojos formation, 178 feet above 18-foot-high ledge, 20 feet below *Mexicaspis* bed, saddle.
Mexicella mexicana Lochman.
Mexicaspis stenopyge Lochman.

801L. Arrojos formation, *Mexicaspis* bed, 198 feet above high ledge in saddle, 736 feet above base of formation.
Wimanella species.
Mexicella mexicana Lochman.
Mexicaspis stenopyge Lochman.
Hyolithes sonora Lochman.

801m. Arrojos formation, 50 feet above *Mexicaspis* bed, east side saddle.
Glossopleura leona Lochman.
Pachyaspis isabella Lochman.
Girvanella cf. *G. sinensis* Yabe.

801m'. Arrojos formation, shaly beds with *Glossopleura* between 801m and 801n.
Glossopleura species.

801n. Arrojos formation, *Kootenia* beds, top of hard ledge on east slope above saddle.
Diraphora arrojosensis Cooper.
Pachyaspis isabella Lochman.
Athabaskia bela (Walcott).
Alokistocare modestum Lochman.
Alokistocarella mexicana Lochman.
Kistocare corbini Lochman.
Kootenia exilaxata Deiss.
Hyolithes sonora Lochman.
Chancelloria eros Walcott.
Glossopleura leona Lochman.
Zacanthoides aff. *Z. holopygus* Resser.

801-O Arroyos formation, shaly beds between *Kootenia* beds and Tren dolomite.
Diraphora arrojosensis Cooper.
Alokistocare althea Walcott.
Hyolithes sonora Lochman.

801p. Arrojos formation, *Albertella* beds, saddle, east side, Proveedora Hills.
Albertella proveedora Lochman.

801q. Lower Cambrian, small hill 0.7 mile N. 23° W. of west end of the Proveedora Hills.
Ajacicyathus rimouski Okulitch.
Syringocnema? species.
Ethmophyllum americanum Okulitch.
E. whitneyi Meek.

801q'. Lower Cambrian, just under pleosponge reef.
Hyolithes aff. *H. princeps* Billings.

801t. Buelna formation.
Salterella mexicana Lochman.

801y. Lower Cambrian, pleospongian reef 0.8 mile N. 48° W. of 801q, west of Caborca, Sonora.
Archaeocyathus yavorskii (Vologdin).
Ajacicyathus nevadensis (Okulitch).
Ethmophyllum cooperi Okulitch.

Locality 802. Difuntos Hills, 14 miles northwest of Caborca, Sonora.

802a. Arrojos formation, 30-35 feet above the valley floor, near the base of the western hill at its northern end.
Mexicella mexicana Lochman.
Mexicaspis difuntosensis Lochman.
Albertella aff. *A. proveedora* Lochman.
Pachyaspis species undetermined.

802b. Arrojos formation, about 110 feet above the valley floor, north end of west hill.
Mexicella mexicana Lochman.
Mexicaspis difuntosensis Lochman.
Glossopleura leona Lochman.
Kochaspis aff. *K. celer* (Walcott).

802c. Arrojos formation, top 10 to 20 feet, north end west hill.
Pachyaspis deborra Lochman.
Glossopleura leona Lochman.

802d. Upper part of Buelna formation, east hill.
Coscinocyathus species.
Protopharetra species.
Cambrocyathus cf. *C. occidentalis* Okulitch.

Locality 807. Buelna Hills, 9 miles northwest of Caborca, Sonora.

807a. Lower Cambrian, Proveedora quartzite, west hill.
Scolithus species.

807b. Lower Cambrian, Buelna formation, *Olenellus* zone, west hill.
Olenellus (*Olenellus*) *truemani* Walcott.
Wanneria walcottana buelnaensis Lochman.
Paedeumias puertoblancoensis Lochman.

Hyolithes whitei Resser.
Salterella mexicana Lochman.
Orthotheca buelna Lochman.

807c. Buelna formation. *Antagmus-Onchocephalus* zone, east hill.
Paterina species.
Olenellus (*Olenellus*) *truemani* Walcott.
Paedeumias puertoblancoensis Lochman.
Wanneria species.
Onchocephalus buelnaensis Lochman.
O. mexicanus Lochman.
Salterella mexicana Lochman.

807d. Buelna formation, *Olenellus* zone, east hill.
Olenellus truemani Walcott.
Salterella mexicana Lochman.

807e. Buelna formation, *Olenellus* zone, east hill.
Girvanella mexicana Johnson.
Olenellus (*Olenellus*) *truemani* Walcott.
Paedeumias puertoblancoensis Lochman.
Wanneria species.
Salterella species.

807f. Buelna formation, upper *Salterella* bed, west hill.
Salterella mexicana Lochman.

807g. Buelna formation, upper *Salterella* bed, east hill.
Salterella mexicana Lochman.

807i. Buelna formation, upper *Salterella* bed, west hill.
Salterella mexicana Lochman.

807j. Lower Cambrian, Proveedora formation, quartzite hill 3,750 yards N. 48° W. of west tip of the Proveedora Hills, west of Caborca, Sonora.
Wanneria? species undetermined.

Locality 809. Prieto Hill, 1½ miles southwest of Caborca, Sonora.

809a. Buelna formation, *Antagmus-Onchocephalus* zone, loose on north slope of hill.
Olenellus (*Fremontia*) *fremonti* Walcott.
Paedeumias puertoblancoensis Lochman.
Onchocephalus buelnaensis Lochman.
O. mexicanus Lochman.
Antagmus solitarius Lochman.
A. buttsi (Resser).
Sombrerella mexicana Lochman.
Bonnia sonora Lochman.
Genus and species undetermined 1.
Salterella mexicana Lochman.
S. cf. *S. pulchella* Billings.
Hyolithes whitei Resser.
Scenella cf. *S. reticulata* Billings.

809b. Buelna limestone, *Antagmus-Onchocephalus* zone, beds in place 60 feet below the Cerro Prieto limestone.
Olenellus species.
Onchocephalus mexicanus Lochman.

Hyolithes species.
Salterella mexicana Lochman.

809c. Cerro Prieto formation, upper surface on top of hill.
Girvanella species.

809d. Buelna limestone, *Salterella* bed at base of Cerro Prieto.
Salterella mexicana Lochman.

Locality 811. Lista Blanca, 6-7 miles southwest of Caborca, south side of Magdalena River, Sonora.

811a. Middle Cambrian, slaty beds at west end.
Unidentifiable trilobites.

Locality 812. Cañedo Hill, east side of Caborca, Sonora.

812a. Near top of hill.
Salterella species undetermined.

812b. Lower Cambrian, Puerto Blanco formation (*Obolella* beds), north side of road in pass between Cañedo sediments and igneous rocks.
Obolella mexicana Cooper.
Trilobite fragments.

GIRVANELLA

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(Plate 6)

Girvanella are lime-secreting algae. They form small nodular calcareous masses composed of numerous tiny entwined tubes. They occur in great numbers in the Cambrian rocks of many parts of the world, having been reported from China (Blackwelder, 1907[1]), Manchuria (Yabe, 1912; Yabe and Ozaki, 1930), Australia (Howchin, 1918; Mawson and Madigan, 1930), Canada (Lewis, 1942), France (Mercier, 1934), and many localities in the United States. The United States Geological Survey, in resurveying the Eureka District, Nevada, found *Girvanella* in abundance. Hazzard and Crickmay (1933) mention their occurrence in the eastern Mohave Desert of California and give a good illustration of the rock but do not describe the species. In 1937 Hazzard mentioned their wide distribution in Nevada, Arizona, and California and suggested a comparison with the "*Girvanella*" described by Yabe from Manchuria.

SYSTEMATIC DESCRIPTION

Following the system proposed by Pia (1927 and 1937), the fossils may be classified as follows:

Class: Chlorophyta (possibly Cyanophyta).
Family: Porostromata.
Subfamily: Agathidia.
Genus: *Girvanella* Nicholson and Etheridge, 1880.

GIRVANELLA MEXICANA Johnson, new species

Plate 6, figures 3-5

Description.—Fossils consist of spherical to elliptical pellets measuring 0.5 to 0.9 cm. in diameter, or 0.6 to 1.0 cm. long and 0.3 to 0.5 cm. high, composed of tubular filaments. Tubes have a surprisingly constant diameter of 0.02 to 0.028 mm., with well-defined, rather thick walls (0.002 to 0.0028 mm. thick). The filaments form a feltlike mat. They are not so strongly twisted as in many species of *Girvanella*, as

[1] See references at end of paper, p. 25.

sections show a considerable length of tube. They occasionally branch.

Remarks.—This species has larger tubes and thicker tube walls than any *Girvanella* previously described from the Cambrian. The nearest species is *Girvanella problematica* f. *moniliformis* Hoeg from the Ordovician. However, *G. mexicana* differs in a larger average size tube diameter, thicker walls, and less frequent branching.

Holotype.—U.S.N.M. No. 115658a.

Formation and locality.—Buelna limestone (lower), 807e.

GIRVANELLA cf. SINENSIS Yabe

Plate 6, figures 1, 2

Girvanella sinensis Yabe, Tohoku Imp. Univ. Sci. Reps., ser. 2, vol. 1, No. 1, 7 pp., 2 pls., 1912.

Description.—Fossils consist of elongated, flattened elliptical pellets 1.6 to 2.2 cm. long (average about 1.8 cm.) and 0.6 to 0.9 cm. wide (average 0.7 cm.), usually oriented with long axis nearly parallel to the bedding of the rock. They are composed of small tubelike filaments having a diameter of 0.009 to 0.012 mm., with thin walls (0.0009 to 0.0015 mm. thick). Tubes are highly twisted and entwined. They show branching rarely.

Remarks.—It is customary to separate the species of *Girvanella* on the basis of diameter of tube and thickness of the walls. In appearance and tube diameter this species closely resembles *Girvanella sinensis.* Unfortunately, Yabe did not give the wall thickness. The pellets of the Mexican material are larger than those described from China. However, the author does not consider this to be a very diagnostic feature as pellets of a species frequently show a wide range in size, even in a single hand specimen, and the Mexican specimens show considerable variation. The species is considered to be close to, if not identical with, Yabe's species.

Holotype.—U.S.N.M. No. 115659.

Formation and locality.—Arrojos formation, 801m.

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PLEOSPONGIA

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(PLATES 7-10)

Most of the specimens described herein come from a low hill, a pleospongian reef, 0.7 mile N. 23° W. of the west end of the Proveedora Hills (locality 801q). A few specimens were collected in another pleospongian reef (locality 801y) 0.8 miles N. 48° W. of the preceding locality. A few specimens were taken from the small eastern hill of the Difuntos Hills. The latter specimens are the only ones collected in a sequence. The two reefs west of the west end of the Proveedora Hills may belong anywhere in the Lower Cambrian section. No hint as to their true position was found in fossils associated with the reefs.

These specimens are of more than average interest because they come from a hitherto unrecorded locality and extend the geographic range of the pleosponges. The nearest localities previously described are in the Waucoba Springs-Silver Peak region of California and Nevada. The collection adds several new forms to the list of North American species and indicates a strong similarity to the California and Nevada fauna. In both localities *Ethmophyllum whitneyi* is the most common species. All the genera listed belong to the subclass Archaeocyatha of the class Pleospongia.

LIST OF SPECIES

Ajacicyathus nevadensis (Okulitch).
A. rimouski (Okulitch).
Ethmophyllum whitneyi Meek.
E. cooperi, new species.
E. americanum, new species.
Coscinocyathus species.
Archaeocyathus yavorskii (Vologdin).
Protopharetra species.
Cambrocyathus cf. *occidentalis* Okulitch.
Syringocnema? species.

SYSTEMATIC DESCRIPTION

Class PLEOSPONGIA

Subclass ARCHAEOCYATHA

Order AJACICYATHINA

Family AJACICYATHIDAE

AJACICYATHUS NEVADENSIS (Okulitch)

Plate 7, figures 5, 6; plate 9, figure 4

Archaeocyathus nevadensis OKULITCH, Trans. Roy. Soc. Canada, ser. 3, sect. 4, vol. 29, p. 101, pl. 1, figs. 7-9, 1935.
Ajacicyathus nevadensis OKULITCH, Geol. Soc. Amer. Spec. Pap. No. 48, p. 55, fig. 18a, b, pl. 1, figs. 1, 2, 4, 1943.

A small ajacicyathid usually not exceeding a few millimeters in diameter. Most typical representative of Ajacicyathidae in North America. Represented in the collection by three specimens. Characterized by elongated, tubular cups, with simple parietes with few pores. Both inner and outer walls simple, perforated by numerous small pores.

Hypotype.—U.S.N.M. No. 111815.

Formation and locality.—Lower Cambrian, at Silver Peak, Nev., pleospongian reef, 801y.

AJACICYATHUS RIMOUSKI Okulitch

Plate 9, figure 5

Ajacicyathus rimouski OKULTICH, Geol. Soc. Amer. Spec. Pap. No. 48, p. 58, pl. 2, figs. 4, 5, 1943.

Very small acutely conical cups. Closely related to *Ajacicyathus nevadensis,* from which it differs in parietal coefficient and shape of cup. Represented by one specimen. Poor preservation makes the inner wall appear thickened.

Hypotype.—U.S.N.M. No. 111823.

Formation and locality.—Lower Cambrian, Bic Harbour, Quebec, 801q.

Family ETHMOPHYLLIDAE

ETHMOPHYLLUM WHITNEYI Meek

Plate 8, figures 3-5

Ethmophyllum whitneyi MEEK, Amer. Journ. Sci., ser 2, vol. 45, p. 62, 1868.
E. whitneyi WALCOTT, U. S. Geol. Surv. Bull. 30, p. 81, pl. 4, figs. 1, 1a-h, 1886.

E. whitneyi Okulitch, Geol. Soc. Amer. Spec. Pap. No. 48, p. 65, pl. 3, figs. 1, 3, 4, 8, 1943.

This common species is represented in the collection by 11 specimens. The chief characteristic of the species is its inner wall, which consists of an area of vesicular tissue, one or two rows deep.

The inner wall of *E. whitneyi* is less regular than the wall in *E. cooperi,* new species, which has a very distinct double row of vesicles. The skeletal elements are thin, enclosing large and irregular empty spaces which are in communication with each other. Very few of the vesicles appear completely enclosed. This observation is at variance with illustrations published by Walcott. The vesicles open into the central cavity. In many cases the inner wall is poorly preserved and the identification has to be based on crenulated inner ends of the parietes and the general appearance of the cup.

Hypotypes.—U.S.N.M. Nos. 111818a-c.

Formation and locality.—Lower Cambrian, Silver Peak district, Nev., 801q.

ETHMOPHYLLUM COOPERI Okulitch, new species

Plate 7, figures 1, 2; plate 9, figure 4

The new species is represented in the collection by two specimens, exposed in transverse sections. One is fully developed, the other is young. The species is found in association with *Ethmophyllum whitneyi* and *Ajacicyathus nevadensis.* The new species has a remarkably regular structure of its inner wall which immediately and unmistakably separates it from all other species of *Ethmophyllum.*

General shape.—Unknown, since the specimen is imbedded in a solid fragment of limestone and it seemed unwise to try to clean it out because of the danger of losing it. Total probable diameter 8 mm.

Outer wall.—Not preserved in the adult specimen; thick and simple in the young, with small pores.

Intervallum.—The intervallum, counting the vesicular zone, is 3 mm. wide and contains 26 parietes of the *Ethmophyllum* type, with few or no pores. The parietal coefficient is therefore 3.25. The intervallum coefficient is 3 mm.: 2 mm. or 1.5.

Inner wall.—Complex, of *Ethmophyllum* type. The width of the vesicular zone varies from 1 mm. to 1.5 mm. It consists of two to three rows of very regular, almost completely enclosed vesicles, made of rather thick skeletal elements. Their position suggests that they were in the nature of vertical tubular to prismatic canals only slightly inclined to the axis of the central cavity. Because of this inclination the

canals open into the central cavity. They are also in communication with each other and the zone of regular parietes by means of smaller openings, and in places directly open into the interparietal space.

The central cavity is devoid of any skeletal tissue.

Nepionic stage.—The second specimen is at the 6-paries stage and has a diameter of about 1 mm. The outer and inner walls, as well as the parietes are very thick. The inner wall shows the early development of the vertical canals as minute circular tubes extending vertically down the wall. If it were not for this feature the specimen could be taken for a young ajacicyathid. It is therefore to be assumed that the spitz is of ajacicyathid type.

The species differs from other Ethmophyllidae in the regularity of the vesicular zone of its inner wall, the completely enclosed, tubular, or canal-like vesicles two or three rows deep, and the parietal and intervallum coefficients.

Types.—Holotype, U.S.N.M. No. 111814; paratype, U.S.N.M. No. 111814a.

Formation and locality.—Lower Cambrian, pleospongian reef, 801y.

ETHMOPHYLLUM AMERICANUM Okulitch, new species

Plate 7, figures 3, 4

This species is represented in the collection by four specimens. It can be best recognized from a transverse polished or thin section. It has a surprisingly strong resemblance to the Siberian genus *Clathrocyathus,* but conventional outer-wall pores rather than the slitlike ones of *Clathrocyathus* place it with *Ethmophyllum.* It differs from all other American species of *Ethmophyllum* by its very narrow intervallum and large number of parietes.

General shape.—Long, tapering conical. Diameter of 9 to 10 mm. Width of intervallum is 1 mm. where diameter of central cavity is 7 mm., giving an intervallum coefficient of 1 mm.: 7 mm. or 0.142.

Outer wall.—Thin with numerous small pores arranged in quincunx, five to eight rows of pores per intersept. Pores in places appear clathriform where the wall has become thickened. Thickness of outer wall is 0.054 mm.

Intervallum.—Very narrow for the size of the cup, resembling the intervallum of *Clathrocyathus* or *Cambrocyathus profundus* in this respect. Intervallum coefficient varies from 0.142 to 0.162. The intervallum is crossed by numerous straight, radial parietes. The number of parietes is 4 per millimeter, or about 72 for the entire cup, resulting in a very constant parietal coefficient of 7.6. There are no visible pores in the parietes.

Inner wall.—Complex, of *Ethmophyllum* type. Consists mainly of a single row of elliptical vesicles or S-shaped imbricating skeletal elements with large openings directed obliquely into the intervallum area and the central cavity. Some of the free edges of the S-shaped elements project into the central cavity. The wall is 0.2 mm. thick.

Central cavity.—Large, with a diameter of 7 mm. Contains no other skeletal tissue except the projecting edges of the inner wall. Young stages unknown, but presumably with a spitz of ajacicyathid type. Possibly related to the Siberian genus *Clathrocyathus,* but more probably an *Ethmophyllum.*

Holotype.—U.S.N.M. No. 111816.

Formation and locality.—Lower Cambrian, 801q.

Family COSCINOCYATHIDAE

COSCINOCYATHUS species

Plate 9, figures 1A, 2

On the same piece of limestone with *Cambrocyathus occidentalis* is a naturally weathered longitudinal section of a *Coscinocyathus.* The preservation is poor and it is impossible to distinguish the details of intervallum structures. There appear, however, to be the usual arched porous tabulae inclined inward and downward. The inner wall appears to be simple, with a single row of pores per intersept. At the base is an indication of some vesicular tissue. This characteristic may possibly indicate that the specimen is a *Metacoscinus* or *Archaeosycon* and not a *Coscinocyathus.*

Holotype.—U.S.N.M. No. 111820.

Formation and locality.—Upper Buelna formation, 802d.

Order METACYATHINA

Family ARCHAEOCYATHIDAE

ARCHAEOCYATHUS YAVORSKII (Vologdin)

Plate 10

Spirocyathus yavorskii Vologdin, United Geol. Prosp. Surv., U.S.S.R., 1931, pp. 40, 110, pl. 3, figs. 9-11, pl. 10, fig. 10; idem, 1932, p. 23, pl. 3, figs. 1, 2, pl. 4, figs. 3-6, 8, text fig. 17.

The species is represented in the collection by one specimen. It is the first time that a definitely Siberian species of *Archaeocyathus* has been recognized in North America. It has to be admitted, however, that the highly irregular structure of the intervallum in the genus

Archaeocyathus makes it necessary to form an opinion on general resemblance; and since cases of convergence are known among Archaeocyatha the specimen may belong to a distinct species.

The nearest American form is *Archaeocyathus atlanticus* Billings from the Lower Cambrian of Labrador and Silver Peak region, Nevada. The main distinguishing features are the more open complex intervallum structure consisting of thin curved plates and a different intervallum coefficient from that of *A. atlanticus.*

Original description of Vologdin follows: "The most typical feature of this form is the most exceptional complexity of splitting of its septa. Transverse sections of the cup reveal complicated branching curved lines, from the feebly developed discontinuity of which we may judge on the faintly developed porosity of the septa."

New description:

General shape.—Unknown, but probably subcylindrical to turbinate. Total diameter of cup about 20 mm.

Outer wall.—Somewhat indefinite because it is made of skeletal elements similar to those within the intervallum, in places continuous where the elements are fused together, in others open with projecting ends of taenia extending a short distance beyond the outer wall. Pore pattern probably irregular, the pores fairly large.

Intervallum.—Filled with taenia, continuous and discontinuous. In part taenia completely enclose the empty spaces, in part form a very loose meshwork of curved anastomosing bars and plates. The structure shows a tendency to become more regular toward the inner wall where radial pattern is more obvious and resembles parietes and synapticulae of the Cambrocyathidae. Pores pierce the taenia in many places and more regularly the parietes. Width of intervallum varies from 8 mm. to 10 mm. while the diameter of inner cavity varies between 6 mm. and 7.5 mm. giving an intervallum coefficient of 8 mm.: 6 mm. or 1.3. This is considerably different from the intervallum coefficient of *A. atlanticus* which is 0.9. It should be pointed out, however, that the intervallum coefficient is variable and not entirely dependable as a specific characteristic. The more constant parietal coefficient cannot be applied to *Archaeocyathus* as regular radical septa are practically lacking.

Inner wall.—Indistinct, made of much thinner elements than outer wall, pierced by numerous small pores.

Central cavity.—Narrow, probably tubular or turbinate, with no vesicular tissue in the upper portion. Condition of lower portion and spitz unknown.

Hypotype.—U.S.N.M. No. 111824.

Formation and locality.—Lower Cambrian pleospongian reef, 801y.

PROTOPHARETRA species

Plate 9, figure 1B

On the same piece of limestone with *Coscinocyathus* species described above are several poorly preserved fragments of *Protopharetra.* Genus *Protopharetra* is characterized by an intervallum filled with irregular tissue and a narrow central cavity. These requirements are fulfilled by the specimens. It is likely that the specimens are conspecific with *Protopharetra raymondi* Okulitch, but poor preservation prevents a definite identification.

Formation and locality.—Upper Buelna formation, 802d.

Family CAMBROCYATHIDAE

CAMBROCYATHUS cf. C. OCCIDENTALIS Okulitch, 1943

Plate 9, figure 3

This species is represented by one partly crushed specimen. However, the simple walls, numerous porous parietes with dissepiments, and the very wide intervallum cause it to be identified tentatively as *Cambrocyathus occidentalis.* The species is fairly common in the Lower Cambrian of Silver Peak, Nevada. It is distinguished from the other species of *Cambrocyathus* by having a very wide intervallum with very numerous parietes and synapticulae.

Hypotype.—U.S.N.M. No. 111821.

Formation and locality.—Upper Buelna formation, 802d.

Order SYRINGOCNEMINA

Family SYRINGOCNEMIDAE

SYRINGOCNEMA? species

Plate 8, figures 1, 2; plate 9, figures 6, 7

Three specimens in the collection, evidently belonging to the same species, could not be definitely identified. The mode of preservation is mostly responsible. The specimens, as seen on the weathered surface of the limestone, appeared in oblique longitudinal section. Attempts to polish them gave very little additional information, and the granular nature of limestone in another case prevented the making of a thin section. The organism consists of two walls. The inner and

outer walls are apparently connected by tubes or canals of very thin curved plates. The canals are irregular in cross section, but tend to be hexagonal and are directed outward and downward.

The inner and outer walls are actually made of the ends of these transverse radial tubes and appear as a slender meshwork, each loop of which represents the opening of a tube. The width of the intervallum is small; in the widest part of the specimen not exceeding one-fourth of the diameter of the central cavity. The general shape is tapering tubular, with a diameter of some 6 mm. for a length of 40 mm. Transverse sections were unobtainable, but consideration of the structure suggests that a transverse thin section would resemble that of an *Ethmophyllum* with a very narrow intervallum, and somewhat vesicular inner wall.

A search through the literature indicates that no comparable pleosponge was previously collected in North America. The nearest in general appearance and structure would be the Australian genus *Syringocnema* originally described by Taylor (1910) and later amended by Bedford (1936). However, our specimens seem to be distinct from the *Syringocnema favus* Taylor. A more definite description will have to wait until better material is found.

Figured specimens.—U.S.N.M. Nos. 111817a, b.

Formation and locality.—Lower Cambrian, 801q.

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BRACHIOPODA

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(PLATES 11-13)

INTRODUCTION

Brachiopods can be easily recognized by their bilateral symmetry. The animals possess two shells, which are unequal in size when viewed from the side. When seen from the front, with the beaks vertical, one half of the shell is the mirror image of the other half. The shells were attached to the sea bottom or hard objects by a peduncle protruded from an opening in or under the beak of the larger valve. The brachiopods may be divided into two major groups by the nature of their shell. One group is characterized by a horny shell and the valves of this group are held together only by muscles. The other group has calcareous shells and the valves are fastened together by teeth and sockets. In the Cambrian both of these groups occur but the former is more abundant than the latter. Furthermore, the articulated brachiopods of the Cambrian are quite simple types.

Brachiopods are not usually common in Cambrian rocks anywhere, but when found many individuals of the same species may occur together. Seldom is a variety of genera and species found in the same layer. In the Cambrian near Caborca brachiopods are common at the base of the Puerto Blanco formation and there give their name to the lower faunal zone (*Obolella* beds). They are fairly common in parts of the Arrojos formation but in other beds they are generally rare animals.

It is seldom that the articulated brachiopods are found in good preservation or that their shells are recovered with both inner and outer surfaces revealed. The locality in the Arrojos formation (locality 800c) that yielded *Diraphora arrojosensis* is unusual in this respect.

Usually the brachiopods having a horny shell are difficult to obtain in a condition suitable for careful study unless treated chemically. These shells, which are insoluble in acetic acid, may be freed from limestone by dissolving the matrix away. The shells remain in exquisite perfection but they are often so delicate and fragile that they are handled or photographed only with the greatest difficulty. The Sonora

Cambrian contains a number of localities that produce excellent material for etching. The base of the Arrojos formation in the Arrojos Hills (locality 800a) yields *Pegmatreta* in abundance and *Acrothele* and *Dictyonina* uncommonly. The base of the Tren limestone (locality 800q) in the Arrojos hills is another excellent locality for this type of material.

DESCRIPTION

Genus LINGULELLA Salter, 1866

Linguloidal, rounded or longitudinally oval in outline, biconvex in profile; surface marked by concentric lines and undulations of growth; pedicle valve with bluntly pointed beak and long pedicle groove; brachial valve with rounded beak and thickened posterior inner margin.

LINGULELLA PROVEEDORENSIS Cooper, new species

Plate 13B, figures 4-6

Shell small for the genus, elongate with the length equal to about $1\frac{1}{2}$ times the width; ornamented by fine concentric growth lines and concentric undulations.

Pedicle valve with acutely pointed beak forming an angle of 77°; lateral margins gently convex but with the anterior margin narrowly convex. Widest at about the middle. Lateral profile evenly and very gently convex with the maximum curvature at about the middle. Anterior profile broadly and gently convex, but more so than the lateral profile. Umbonal region narrowly swollen and with steep umbonal slopes. Narrow umbonal swelling continued anteriorly as a low fold but with anteriorly diminishing slopes to about the middle where a fairly even convexity is maintained to the anterior margin. Anterior and anterolateral slopes, convex, long, and fairly steep.

Brachial valve unevenly convex in lateral profile and with the maximum convexity in the posterior third; anterior profile somewhat narrowly convex, with a well-rounded crest and short, steep lateral slopes. Lateral margins broadly rounded and bending somewhat abruptly into the posterolateral margins to give definite shoulders and a subpentagonal form. Apical angle 115°. Anterior margin narrowly rounded. Umbonal region broadly swollen, the swelling gradually merging into the more gentle convexity of the anterior half. Posterolateral slopes short and steep, becoming progressively less steep anteriorly where the lateral slopes are moderately steep. Anterior slope nearly flat, long and gentle.

Interior.—Details difficult to ascertain and none obtained from the

pedicle valve. Brachial interior with thick low ridge extending from near the beak to about the middle.

MEASUREMENTS IN MM.

	Length	Greatest width
Holotype, pedicle valve	6.5	4.6
Paratype, brachial valve, U.S.N.M. No. 116040a	6.1	4.2
Paratype, brachial valve, U.S.N.M. No. 116039b	5.1	3.8
Paratype, brachial valve, U.S.N.M. No. 116039d	5.2	3.7

Types.—Holotype, U.S.N.M. No. 116039a; figured paratypes, U.S.N.M. Nos. 116039b, 116040c; unfigured paratypes, U.S.N.M. Nos. 116040a, b, 116039b-d.

Formation and locality.—Puerto Blanco formation (*Lingulella* bed) west end, Proveedora Hills, 801b.

Discussion.— Few species of *Lingulella* are known from the Lower Cambrian. This one is similar to *L. granvillensis* Walcott in size and proportions, but has a somewhat more attenuated pedicle valve and a brachial valve with broader shoulders. Furthermore, the interiors of the two species do not agree because the broad and pronounced ridges of the Mexican species are not present in the New York and Vermont specimens.

Genus PATERINA Beecher, 1891

Subcircular to subrectangular in outline; valves of unequal depth, the pedicle being the deeper; pedicle valve hemiconical, brachial valve moderately convex; surface marked by fairly regular elevated concentric lines. Pedicle valve with more or less strongly developed homoeodeltidium. Interior poorly known.

PATERINA species

Plate 11B, figures 7, 8

Shell small for the genus, conical in profile and subcircular in outline; sides and anterior margin rounded; surface marked by strong regular concentric lines.

Pedicle valve forming a misshapen cone; lateral profile moderately convex with the maximum convexity at about the middle; anterior profile strongly convex; median region swollen; umbo and beak prominent. Brachial valve moderately convex in both profiles; median region swollen with moderately long and moderately steep lateral slopes.

Pedicle valve length 1.7 mm., width 1.9 mm., brachial valve length 1.5 mm., width 2.0 mm.

Figured specimens.—U.S.N.M. Nos. 116050a, b.

Formation and locality.— Buelna formation, 807c.

Discussion.—These small specimens seem to be young. The pedicle valve is strongly convex, more so than any known species, but it is fruitless to compare them to adult specimens.

Genus MICROMITRA Meek, 1873

Outline, profile, and homoeodeltidium like that of *Paterina,* but surface marked by irregular elevated radial lines crossing the concentric ones.

MICROMITRA species

Plate 13 A, figures 1-3

Transversely but broadly elliptical in outline, sides rounded; anterior margin broadly rounded; surface marked by fine, even, elevated concentric lines and irregular radial wrinkles, about five wrinkles to a millimeter at the front margin.

Pedicle valve subconical in outline; gently convex in lateral profile but with the maximum curvature at the umbo; anterior profile strongly convex; beak forming highest part of cone, narrowly rounded and protruding slightly; umbonal and median region full; sides narrowly rounded and steep.

Brachial valve with less-elevated beak than pedicle valve; lateral profile moderately convex; anterior profile strongly convex but less so than the pedicle valve; umbonal region slightly inflated; median region full; umbonal slopes short but gently concave.

MEASUREMENTS IN MM.

	Length	Width	Thickness
Pedicle valve, U.S.N.M. No. 116046a......	2.9	3.5	1.0
Brachial valve, U.S.N.M. No. 116046c.....	3.2	4.6	0.9

Specimens.—Figured specimens, U.S.N.M. Nos. 116046a-c; unfigured specimen, U.S.N.M. No. 116046d.

Formation and locality.—Base of Arrojos formation, 800a.

Discussion.—The specimens of this species are too fragmentary to warrant a specific name. Nevertheless they cannot be identified with any described species.

Genus DICTYONINA Cooper, 1942

Like *Paterina* and *Micromitra* in outline, profile, and homoeodeltidium but external ornamentation consisting of oblique raised lines which produce quincuncially arranged minute pits.

DICTYONINA MINUTIPUNCTA Cooper, new species

Plate 11 A, figures 1-6

Shell large for the genus, transversely elliptical in outline; biconvex in profile; lateral and anterior margins rounded; surface marked by concentric growth undulations and fine lines of growth, radial wrinkles irregularly arranged and possibly produced by flowage within the limestone and small closely crowded transversely elliptical pits.

Pedicle valve gently convex in lateral profile with the greatest convexity located in the posterior half and anterior half flattened; anterior profile narrowly convex in the median region but sloping fairly steeply on the sides; umbonal region narrowly swollen and prominent, the swelling extending somewhat anterior to the middle where it merges into the flattening anterior portion; umbonal slopes steep and concave; homoeodeltidium short and very thick, forming a callosity at the beak. Apical angle about 125°-140°.

Brachial valve gently convex in lateral profile and broadly convex in anterior profile; beak small, marginal.

MEASUREMENTS IN MM.

	Length	Width	Thickness
Holotype, pedicle valve........................	10.4plus	11.3	2.0?
Paratype, brachial valve, U.S.N.M. No. 116045b..	9.5	10.5	1.0?

Types.—Holotype, U.S.N.M. No. 116045a; figured paratypes, U.S.N.M. Nos. 116045b-d; unfigured paratypes, U.S.N.M. Nos. 116045e-h.

Formation and locality.—Uppermost Arrojos formation (*Acrothele* bed), 800f.

Discussion.—This species is characterized by its erect pedicle beak, small homoeodeltidium, fairly large size, and the fine, densely pitted surface. It is suggestive of *D. burgessensis* (Resser) but is more finely ornamented. This feature separates the species from other members of this genus except *D. nyssa* (Walcott), which is a finely ornamented species, but it occurs in a soft shale and the specimens available are too badly crushed to show its true shape.

DICTYONINA species

Plate 12 B, figures 7-9

A second species of *Dictyonina* is much smaller than the preceding and with considerably different external form. Indications point to the umbo of the pedicle valve as not being so narrowly convex and prominent as in *D. minutipuncta;* the ornamentation is somewhat stronger than that of the preceding. Its combination of characters is not like those of any known species but the specimens are too poor for description.

Figured specimens.—U.S.N.M. Nos. 116044a, d, e.

Formation and locality.—Tren formation (basal 12 feet of limestone), 800g.

Genus OBOLELLA Billings, 1861

Valves subcircular to longitudinally oval in outline, subequally convex in profile; surface marked by concentric lines and undulations of growth, and, when well preserved, by radiating costellae. Pedicle valve with a minute foramen located slightly anterior to the beak.

OBOLELLA MEXICANA Cooper, new species

Plate 12 D, figures 20-31

Shell small for the genus, subcircular to oval in outline, biconvex, the brachial valve having the greater convexity; surface marked by concentric lines of growth.

Pedicle valve with lateral and anterior margins strongly rounded; posterior produced into an acutely pointed beak. Lateral profile gently convex, with the greatest convexity in the posterior half; anterior half somewhat flattened. Anterior profile broadly and gently convex. Beak long and sharply pointed, very slightly incurved. Pseudointerarea broad. Umbonal cavities moderately deep; opening of pedicle tube on interior large, located just anterior to the umbonal cavities. Muscular and pallial markings not discernible.

Brachial valve nearly circular in outline; fairly evenly and moderately convex in lateral profile; broadly and gently convex in anterior profile. Median sulcus shallow, narrow, extending from the umbo to the anterior margin. Umbonal region moderately swollen. Brachial interior with well-defined posterolateral ridges and a low median elevation, but other details of the musculature and pallial markings not defined.

MEASUREMENTS IN MM.

	Length	Width
Holotype	9.5	10.0
Paratype, U.S.N.M. No. 116056a	5.5	6.5
Paratype, U.S.N.M. No. 116051c	6.0	6.5
Paratype, U.S.N.M. No. 116051d	5.0	5.1

Types.—Holotype, U.S.N.M. No. 116056b; figured paratypes, U.S.N.M. Nos. 116056a, c, 116041a, c, d, f, 116051c, e, f; unfigured paratypes, U.S.N.M. Nos. 116041b, e, 116051a, b, d.

Formation and locality.—Puerto Blanco formation, 801b, 812b.

Discussion.—This is a small species characterized by its nearly circular form and the low convexity of both valves. In these respects it differs from *O. chromatica* Billings which is a strongly convex species. *Obolella crassa* (Hall) is a much larger species and has a different outline and more convex valves. *Obolella atlantica* Walcott is close but is generally larger and the valves somewhat more convex.

It is interesting to note that this genus commonly is found in crystalline limestone. The Mexican specimens occur in a pinkish crystalline matrix which is highly siliceous. When weathered the *Obolella* shells appear as imprints in a punky brown residue. When fresh the shells have a dull brownish color. *Obolella chromatica, atlantica,* and *crassa* occur in crystalline limestone. The former two are in matrix very much like that of the Mexican specimens, a pinkish limestone with pearly luster. A few specimens of *O. mexicana* were taken from white marble.

Genus PEGMATRETA Bell, 1941

Shells minute; pedicle valve a misshapen cone with short posterior pseudointerarea and minute foramen. Pedicle interior with large boss just anterior to foramen and two strong divergent pallial trunks. Brachial valve circular in outline, more or less strongly convex; brachial interior without propareas and with a long, more or less elevated median septum.

PEGMATRETA RARA Cooper, new species

Plate 12 C, figures 10-19

Shell small, forming a low, circular cone in outline; surface marked by fine, elevated concentric lines. Foramen minute.

Pedicle valve gently convex in lateral profile with the deepest part in the umbonal region; anterior slope long and gently convex, steepening somewhat near the front margin; lateral profile somewhat narrowly

convex and with long, steep, flat sides, posterior slope short and steep; interior with a small, short pedicle callosity, vascula media widely divergent. Pseudointerarea narrow; intertrough shallow, narrow.

Brachial valve fairly evenly and strongly convex in lateral profile, the greatest depth at about the middle; umbo curved in lateral profile; anterior profile broadly convex with a flattened median area, but short, moderately steep sides. Beak small, marginal; umbo inconspicuous; median region swollen and with fairly steep slopes to the margins; sulcus inconspicuous, narrow, extending from the umbo to the front margin. Interior with a long but low median ridge; triangular pit small, deep. Propareas wide but short.

MEASUREMENTS IN MM.

	Length	Width	Thickness
Holotype	2.2	2.5	1.0
Paratype, pedicle valve, U.S.N.M. No. 116059a	2.4	2.9	0.8
Paratype, brachial valve, U.S.N.M. No. 116059b	2.3	3.0	0.5

Types.—Holotype, U.S.N.M. No. 116057d; figured paratypes, U.S.N.M. Nos. 116057a-c, 116059a, b, d, f, g; unfigured paratypes, U.S.N.M. Nos. 116059c, e.

Formation and locality.—Base of Arrojos formation, 800a.

Discussion.—This species differs from *P. arellanoi* in its much rounder outline, longer pseudointerarea, less convex profile, more greatly developed subapical callosity in the pedicle valve, and a less elevated median septum in the brachial valve.

PEGMATRETA ARELLANOI Cooper, new species

Plate 13 C, figures 7-12

Shell minute, forming a depressed cone, elongate oval in outline; sides gently rounded; anterior margin narrowly rounded; surface marked by fine concentric lines of growth.

Pedicle valve a depressed cone with a short and steep posterior slope but long and gently convex anterior slope; greatest convexity located at about the middle; inside the pedicle valve the preforaminal swelling is short, narrow, prominent.

Brachial valve almost circular in outline, fairly strongly convex in lateral profile and about equally convex in anterior profile; interior with a median septum extending from the posterior margin nearly to the anterior margin; septum separating two large muscle scars at the posterior end.

MEASUREMENTS IN MM.

	Length	Width	Thickness
Paratype, pedicle valve, U.S.N.M. No. 116058a..	1.8	1.6	0.3
Paratype, brachial valve, U.S.N.M. No. 116058c.	1.8	1.8	0.3

Types.—Holotype, U.S.N.M. No. 116058f; figured paratypes, U.S.N.M. Nos. 116058a, c, e, h; unfigured paratypes, U.S.N.M. Nos. 116058b, d, g.

Formation and locality.—Tren formation (basal 12 feet), 800g.

Discussion.—This species is characterized by its short pseudointerarea, strongly oblique conical form and strong biconvexity. It differs from *P. rotunda* Bell in its apsacline and shorter pseudointerarea, longitudinally oval outline and strongly convex brachial valve. *Pegmatreta perplexa* Bell is also a transversely elliptical form and therefore differs markedly from *P. arellanoi.*

Genus ACROTHELE Linnarsson, 1876

Valves unequal in depth, circular in outline; pedicle valve an irregular cone with a small round foramen on the posterior slope; interior with two widely divergent pallial trunks. Brachial valve gently convex in lateral and anterior profiles. Surface marked by concentric lines and a dense mat of minute pustules.

ACROTHELE CONCAVA Cooper, new species

Plate 12 A, figures 1-6

Shell of about usual size for the genus, subcircular to transversely elliptical in outline; all margins strongly rounded. Surface marked by strong, somewhat wavy concentric undulations Obscure radial markings occur on the median portions of each valve and extend from the beak to the anterior margins.

Pedicle valve conical, with the apex of the cone located about one-fifth the length from the posterior margin. In lateral profile the anterior slope long and moderately concave; posterior slope flat to gently convex. Lateral slopes steeper than anterior slope and moderately concave. Foramen small, longitudinally and narrowly elliptical, located very slightly posterior to the apex. Pseudointerarea moderately broad, nearly flat but with a faintly impressed median groove extending posteriorly from the foramen to the posterior margin.

Brachial valve very gently convex in lateral and interior profiles; umbonal and posterior regions forming a broad and moderately deeply depressed basin. Anterior and lateral areas gently convex. Beak

slightly anterior to the posterior margin and formed of two shiny points with a short, shallow depression extending a short distance anterior to them.

MEASUREMENTS IN MM.

	Length	Width	Thickness
Holotype	8.5	9.8	3.1
Paratype, pedicle valve, U.S.N.M. No. 116035c	4.4	5.1	1.4
Paratype, brachial valve, U.S.N.M. No. 116035a	8.2	9.3	?

Types.—Holotype, U.S.N.M. No. 116035d; figured paratypes, U.S.N.M. Nos. 116035a, c; unfigured paratypes, U.S.N.M. Nos. 116035b, e, f.

Formation and locality.—Uppermost Arrojos formation, 800f.

Discussion.—This species is most strongly suggestive of *A. colleni* Walcott in its strongly concave brachial umbo and strongly pyramidal pedicle valve. It differs from the Montana species, however, in having the umbonal concavity covering a somewhat larger area of the posterior and in having a greater convexity of the median area. The pseudointerarea of the pedicle valve of the Mexican species is broader than that of *A. colleni,* the apex of the latter is narrower than that of *A. concava.* The anterior slope is more concave in the Montana species than that of *A. concava.*

Inasmuch as the preservation of the two species is quite different, some of the variations between them may be accounted for by the fact that *Acrothele colleni* occurs in a soft shale and some of the specimens are crushed. *Acrothele concava* occurs in a limestone which shows some signs of flowage. It is therefore difficult to determine the true characters with precision. It seems best to establish the Mexican form as a new species because of the definiteness of its characters, while at the same time admitting the close resemblance.

Genus NISUSIA Walcott, 1905

Valves unusual in depth, the pedicle valve hemiconical, the brachial valve gently convex in lateral profile; surface multicostellate. Delthyrium covered by a convex pseudodeltidium; pedicle apex perforated by a large round foramen; interior with incipient dental plates. Brachial valve sulcate and with primitive brachiophores.

NISUSIA species

Plate 13 F, figures 26, 27

Shell of about the usual size for the genus; wider than long, with the hinge equal to, or slightly less than, the width at the middle; car-

dinal extremities acute or nearly rectangular, depending on age. Anterior commissure rectimarginate. Lateral margins gently convex; anterior emarginate because both valves are sulcate. Ornamentation difficult to ascertain in exfoliated specimens, but seems to consist of distant and somewhat irregularly arranged costellae.

Pedicle valve hemiconical in lateral profile but broadly and gently convex in anterior profile and with the median region indented by the sulcus. Umbonal region somewhat elongated and moderately convex, terminating in a narrow beak truncated at its apex by a round foramen. Sulcus originating near beak and extending to anterior margin, shallow and narrow. Flanks bounding sulcus moderately swollen and elevated above sulcus. Slopes to cardinal extremities long and moderately steep. Interarea moderately long, steeply apsacline; pseudodeltidium short, strongly arched.

Brachial valve gently convex in lateral profile; moderately convex and medianly depressed in anterior profile. Umbonal region moderately swollen and protruded posterior to the posterior margin. Sulcus originating on umbo, narrow and shallow and extending to the anterior margin. Flanks somewhat narrowly swollen with steep slopes to the lateral margins and cardinal extremities.

Interior details of both valves obscure.

Measurements.—Not one of the specimens available for study is sufficiently complete to take measurements, but the species must have been a fairly large one having a length of at least 12.5 mm. and a width of about 17 mm.

Figured specimens.—U.S.N.M. Nos. 116037b, c.

Formation and locality.—Basal Arrojos formation, 801h.

Discussion.—Inasmuch as all the specimens are shorn of their shells and only impressions of the interior are preserved, it is impossible to make detailed comparisons with other better-preserved species. It is evident that the Mexican shells represent a large form perhaps suggestive of *N. deissi* Bell or *N. montanensis* Bell.

Genus WIMANELLA Walcott, 1908

Thin-shelled; subquadrate to subsemicircular; hinge-line straight; biconvex, the pedicle valve having the greater depth; delthyrium open; surface covered by fine concentric lines of growth; pedicle interior with large diductor muscle scars tapering anteriorly, separated dorsally by a low ridge which forks anteriorly about the adductor impression; vascula media prominent. Brachiophores short; billingsellid median ridge low; no cardinal process.

WIMANELLA species

Plate 13 D, figures 13, 14

Small for the genus, subrectangular in outline; wider than long, with the hinge forming the widest part. Sides sloping gently toward the middle; anterior margin broadly rounded. Lateral profile moderately convex; anterior profile fairly strongly convex; surface marked by concentric lines of growth.

Measurements.—Length of figured specimen U.S.N.M. No. 116054, 7.9 mm.; midwidth, 8.7 mm.; hinge width, 9.0 mm.

Figured specimens.—U.S.N.M. Nos. 116054, 116055a.

Formation and locality.—Middle Arrojos formation, 801L.

Discussion.—This species is not quite like any other described, but, because it is known from three specimens only, and all of them are small, one cannot be certan that he is dealing with an adult. Consequently, the species is not named. Most of the known species of *Wimanella* are much larger than this one and generally have a more quadrate outline. This is true of *Wimanella rossensis* Resser which is only a moderate-sized shell. The Manchurian species *W. takayamai* Resser and Endo is comparable in size, but it is much more convex and more transverse.

Genus DIRAPHORA Bell, 1941

Like *Wimanella* in outline and profiles and with open delthyrium and notothyrium, but surface marked by radial costellae.

DIRAPHORA ARROJOSENSIS Cooper, new species

Plate 13 E, figures 15-25

Shell of about medium size for the genus; subrectangular in outline and slightly wider than long; hinge usually narrower than the greatest shell-width, which is near the middle; cardinal extremities usually obtuse; young specimens with hinge slightly wider than shell at middle and with acutely angular cardinal extremities; lateral margins usually gently convex, but nearly straight or slightly concave if cardinal extremities are acute; anterior margin broadly rounded. Anterior commissure sulcate in young but becoming rectimarginate in mature specimens. Ornamentation consisting of narrowly rounded costellae separated by interspaces equal in size to, or narrower than, the costellae. In a specimen 6 mm. long, 4 or 5 costellae occur in a space of 1 mm. at the front margin.

Pedicle valve strongly convex in lateral profile with the greatest convexity in the posterior half; anterior profile narrowly convex with

steeply sloping sides. Umbo narrowly convex; beak narrow and strongly incurved. Narrowed umbo continued anterior to about the middle as a low fold, but anterior to the middle the convexity gradually decreases to the front margin. Posterolateral slopes steep and gently concave in profile. Anterolateral and anterior slopes moderately convex. Interior moderately long, strongly curved and generally apsacline.

Brachial valve gently to moderately convex in lateral profile in adults but nearly flat in the young; anterior profile nearly flat to broadly and gently convex. Umbonal region sulcate; sulcus well defined, originating in a pit at the umbo, moderately deep in the posterior third to half, but becoming shallow or barely perceptible in the anterior portions. Flanks gently convex; cardinal extremities depressed toward the pedicle valve.

Pedicle interior without dental places; delthyrial cavity moderately deep; adductor track moderately wide; diductor tracks narrow, continuous with the pallial trunks which are not widely separated. Brachial valve with incipient cardinal process, short, stout brachiophores and strongly impressed adductor scars.

MEASUREMENTS IN MM.

	Length	Width	Hinge width	Thickness
Pedicle valve, U.S.N.M. No. 116042a	7.6	9.2	8.6	2.8
Pedicle valve, U.S.N.M. No. 116042b	9.6	10.0	9.0	2.6
Paratypes, brachial valve, U.S.N.M. No. 116042c	7.0	8.5	8.2	?
Brachial valve, U.S.N.M. No. 116042d	8.6	9.9	7.8	0.7

Types.—Holotype, U.S.N.M. No. 116042h; figured paratypes, U.S.N.M. Nos. 116042c, e, g, i, j, 116048a-c; unfigured paratypes, U.S.N.M. Nos. 116042a, b, d, f.

Formation and localities.—Arrojos formation, 800c, 801n, 801-O.

Discussion.—This species is characterized by its small size, compact and thick shell, and the fairly uniform character of the costellae. It differs from *D. bellicostata* (Walcott) in its smaller size, more rounded form, and more finely costellate valves.

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THE ORIGINAL COLLECTION OF CAMBRIAN TRILOBITES FROM SONORA

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(PLATE 14)

INTRODUCTION

Discovery of Cambrian faunas in Mexico in general, and in Sonora in particular, dates from the time (1941) when Isauro G. Gómez L. and L. Torres, two Mexican geologists then working in Sonora on behalf of Petróleos Mexicanos, brought to me for identification and stratigraphic interpretation the fossils collected in the Magdalena River Valley, northwestern Sonora. After identification of specimens it was agreed, upon the writer's suggestion, that the name "Arrojos formation" should be applied to the strata characterized by the collected Middle Cambrian trilobites, whereas the underlying beds with algal structures, presumably of pre-Cambrian age, should be referred to as the Jojoba formation.

I was unable to find in the geological literature any previous indication of the presence of Cambrian fossils in Mexico. In either of the two best-known treatises dealing with the Paleozoic stratigraphy of that country—Schuchert's "Historical Geology of the Antillean-Caribbean Region, or the Land Bordering the Gulf of Mexico and the Caribbean Sea" (1935) and R. E. King's "Geological Reconnaissance in Northern Sierra Madre Occidental of Mexico" (1939)—and likewise in the publications listed as references in these works, there was no mention of the age of any strata as Cambrian based on paleontological evidence. Realizing that there might have been relevant indications in the undescribed material preserved in the United States National Museum and the United States Geological Survey, I interrogated Dr. C. E. Resser and Dr. J. Bridge on this matter, forwarding photographic pictures of the specimens examined. Both scientists answered in the negative. Dr. Bridge wrote (January 22, 1942):

> I know of no Cambrian in Sonora, other than the problematical Cambrian just across the border near Bisbee. I think that this has been discussed by Taliaferro, but he had no fossils, and the correlation was purely on lithology and position.
>
> Resser knows of none.

> I have just called Philip King, whose brother has done a lot of work in Sonora, and I have also talked to Ralph Imlay, who has worked there himself, and neither of them knows of any, although they both admit that there is a possibility such as you suggest.
>
> It would appear that you have something new, and I sincerely hope that you get a statement about it into print as soon as possible. I have always thought that the Cordilleran geosyncline must have opened to the southwest, but I never knew of any evidence for it. I am sure that Dr. Schuchert would be much interested in hearing about this.

The purpose of the present article is a description of the original collection of Gómez and Torres on which the presence of Cambrian strata in Mexico was established. To this is added a description of related specimens collected later under the direction of Dr. G. A. Cooper at the type locality and presumably from the same strata.

None of the photographic illustrations of the fossil specimens has been retouched. Many additional details may be seen with a magnifying glass.

DESCRIPTION

SONORASPIS Stoyanow, new genus

In my announcement on discovery of Cambrian trilobites in Mexico (Stoyanow, 1942, pp. 1263-1264), the specimens collected in the Arrojos Hills by Gómez and Torres were listed as *Glossopleura, Anoria?,* and *Alokistocare.* The incongruity of placing the related Sonora forms under the first two genera presented itself when it became apparent that, while the thorax of Poulsen's and Walcott's genera contained seven segments, the trilobites under description had eight thoracic segments. This characteristic had also been observed in the additional specimens sent to me later by Dr. Cooper. Further studies led to the conclusion that the two species described and illustrated in this paper under *Sonoraspis,* new genus, have mixed features that would make it difficult to place them either under *Glossopleura* or under *Anoria.*

My attention was further attracted by an interesting specimen from the Stephen formation, Mount Bosworth, B. C. (U.S.N.M. No. 62707), included by Walcott in his original description of *Dolichometopus boccar* (Walcott, 1916, p. 363, pl. 52, fig. 1*e*). Although, as stated in "Description of Plate 52," this specimen contains "Pygidium and five thoracic segments flattened in shaly limestone," it may be inferred from the illustration that it has six thoracic segments in the fragmented left side but eight segments in the complete right side. Another specimen, identified by Walcott as *D. productus* (Hall and Whitfield, *in* Walcott, 1916, pl. 53, fig. 2*c*), also may be interpreted

as having eight segments in the left side of the thorax. Resser, queried on this matter, replied (April 3, 1942):

> Regarding the *Glossopleura boccar* to which you refer, 8 segments are visible in the picture and Walcott recorded 5. The specimen is not available for examination, but I would expect to find that the fault is in the drawing. Figure 1*e* is the holotype and you will observe that it has 7 segments. This species is rare and you will find closer affinities with those from the Grand Canyon where I am adding several new ones. All of your species that I have seen are new and should not be identified with any previously described.

It should be noted in this connection that Poulsen (1927, p. 268, footnote) established his genus *Glossopleura* on all syntypes of *Dolichometopus boccar* Walcott. As far as I am aware at present, Resser had never specified in published works his preference for this questionable specimen as the holotype of *Glossopleura boccar,* and in the critical analysis (Resser, 1935, pp. 29-34) of several species under *Glossopleura* he interpreted Walcott's species as based on three syntypes: U.S.N.M. Nos. 62703, 62705, and 62707. Syntype No. 62703 (Walcott, 1916, pl. 52, fig. 1*a*) is better preserved than the rest. Although Resser stated that its cranidial features are imperfect, anterior part of the glabella damaged, and Walcott's photograph foreshortened, he also added that the defective parts are essentially as in the second syntype, U.S.N.M. No. 62705 (Walcott, 1916, pl. 52, fig. 1*c*). As to the third syntype, U.S.N.M. No. 62707, it is probable that Resser had in view to separate it as the holotype, as per his letter above. However, his photograph of this specimen reproduced in Shimer and Shrock's "Index Fossils of North America" (1944, pl. 258, fig. 10) is in no way an improvement over Walcott's drawing; the critical right side of the thorax is blurred so that it is impossible to be sure about the number of segments. Independently of the number of thoracic segments, this type lacks the entire cephalon, and probably the anterior part of the thorax is seriously damaged.

The first critical comparison between *Anoria* and *Glossopleura* was made by Walcott (1916, p. 373) in his original description of *Dolichometopus tontoensis:*

> The species differs from *D. productus* (pl. 53) in having a smaller palpebral lobe, a median spine on each thoracic segment and the anchylosed segments of the axial lobe of the pygidium, also in the enlargement of the fifth thoracic segment. This character is present in the 13 specimens preserving the thorax, and is not present in the 11 associated specimens of *D. productus.* . .
>
> The combination of small eye lobe, median spine on thoracic segments and enlarged fifth thoracic segment, suggests a reversion to primitive characters in this species that might be recognized by a subgeneric name if further investigation justifies it.

Later, when genus *Anoria* was erected (Walcott, 1924, p. 54; 1925, p. 67), the nature and course of facial suture and the presence of tubercles on the anterior axial segments of the pygidium were included in the diagnosis.

Poulsen (1927, p. 268) specified the following principal characteristics as diagnostic of *Glossopleura*: 1, absence of tubercles on the axial segments of thorax and pygidium; 2, lack of macropleural development of the fifth thoracic segment; 3, long palpebral lobes.

Diagnosis.—The new genus *Sonoraspis* is established on two new species, *S. torresi* and *S. gomezi,* and is characterized by two features common to both species: the presence of eight segments in the thorax, unlike *Glossopleura* and *Anoria,* which have only seven thoracic segments, and by absence of macropleural development of the fifth thoracic segment, as in *Glossopleura.* The other principal characteristics are so arranged in these two species that it is impossible to place either of them under Walcott's and Poulsen's genera. So, for instance, in *S. torresi,* which lacks the axial tubercles of *Anoria,* the palpebral lobes are short, as in that genus. On the other hand, in *S. gomezi,* which has the axial tubercles, but only in the posterior segments of the thorax and none on the axis of the pygidium, the palpebral lobes are very long, as they are in *Glossopleura.* Other details are presented in the description of the species. If Walcott was right in his interpretation of *Anoria tontoensis* as a species showing a reversion to more primitive forms, the strata with *Sonoraspis* of northwestern Sonora may be stratigraphically older than the *Anoria-Glossopleura* zone of the Cambrian sequence in the Grand Canyon area of Arizona. Summarily, the diagnosis of *Sonoraspis* is as follows: In general appearance the dorsal shield is as in *Anoria* and *Glossopleura* but with eight thoracic segments. Macropleural development of the fifth thoracic segment is absent. Median tubercles may be present on the posterior segments of the thoracic axis. Pygidium with smooth or weakly segmented axis and without tubercles. Palpebral lobes may be short or long in different species.

It may be argued that the forms with tuberculate and smooth thoracic segments should not be placed in the same genus, as was the case with Resser's (1935, pp. 10-11) grouping together both kinds of species under *Anoria.* There are intermediate forms, *"Anoria" baton* and *"Anoria" bessus* (Walcott, 1916, pl. 51, figs. 2, *2a,* and 3), which have a cephalon of *Anoria* but, as *Glossopleura,* want tubercles on the seven thoracic segments. It may also be noted that probably there are more than two species in the described assemblage. However, considering the very limited amount and nature of the material available,

I believe that a differentiation of the described eight-segmented forms further than on the basis of certain of their major characteristics, observable also in the seven-segmented *Anoria* and *Glossopleura,* respectively, would be unwarranted at this time.

Genotype.—Sonoraspis torresi Stoyanow, new species, is so designated as the first found.

SONORASPIS TORRESI Stoyanow, new species

Plate 14, figures 1-4

The Sonora specimens assigned to this species belong in two sets: (a) two forms represented by a rather large and relatively wide dorsal shield with a gradually tapering axis, as in figures 1 and 2 of plate 14, and (b) two smaller, narrower forms with a more rapidly tapering axis, as shown in figures 3 and 4 of the same plate.

The specimen of the set (a), illustrated in figure 1 of plate 14, is better preserved. Although the anterior of the cephalon is obliterated, the nature of the posterior parts of the glabella and fixed cheeks, and of the posterolateral limbs is clearly indicated on the cranidium. Of importance is the course of the facial suture as inferred from the outline of the fixed cheek. It is as in *Anoria* (compare *A. baton, A. bessus, A. tontoensis,* Walcott, 1916, pl. 51, figs. *2b, 3b;* 1925, pl. 18, fig. 16), that is, the facial suture has a wide and shallow embayment in its posterior part and cuts the posterior border of the cephalon closer to the genal angles, which makes the extremities of the posterolateral limbs rather wide, and not as in *Glossopleura* (compare *G. stephenensis, G. boccar, G. producta,* Walcott, 1916, pl. 52, figs. 1, *1a, 1c;* pl. 53, fig. 2) with the facial suture that forms nearly a right angle between the long palpebral lobes and very narrow, shorter, posterolateral limbs.

In all eight thoracic segments the pleural lobes carry oblique pleural furrows strongly impressed from the proximal upper margin to the pleural facet, and terminate in sharp, bent-backward, pleural spines.

Broad and rather short somewhat subtriangular pygidium has a wide and tapering axis composed of five segments and a terminal section which overlaps the marginal furrow on a broad and concave posterior border with an inflection impressed by the doublure posterior to the axis. With the exception of the axis, there is no evidence of distinct segmentation on the pygidium. This specimen is designated as holotype of the species.

The second specimen of the same set, figure 2 of plate 14, is less satisfactorily preserved, and no part of its cephalon is present. Nevertheless, the eight thoracic segments being clearly indicated and the

general resemblance to the specimen just described rather strong, it is considered as conspecific with the holotype. Pygidium is semioval, with a well-outlined pygidial platform on which only one anterior segment is feebly indicated. Eroded condition of the axis, the terminal part of which overlaps the platform, makes it impossible to infer whether it was segmented. Posterior border is strongly concave, with the impressed doublure visible (with a magnifying glass) in its right half.

The first specimen of the set (b) has the posterior part of the facial suture sufficiently preserved in the right side of the cephalon to see that it was as in *Anoria,* with a shorter palpebral lobe. None of the eight thoracic segments seems to have carried the tubercles, although of this there cannot be an absolute assurance because of eroded condition at the critical parts of the axis. In the suboval pygidium the axis is elevated, semicylindrical, and smooth. However, the anterior segment is feebly indicated on the pygidial platform. This specimen is illustrated in figure 3 of plate 14. Barring the difference is size, it appears to be supplementary to the preceding specimen.

The second specimen of the set (b) is remarkable for its narrow dorsal shield and the rapidly tapering axis. The two visible posterior thoracic segments are free from tubercles. Due to an occasional crack in the posterior right side of the thorax, the last segment appears as macropleural. This is an optical illusion. Actually the pleuron is outlined as its counterpart on the left side. The strongly semicircular pygidium is with a very narrow smooth axis and with an unsegmented pygidial platform. On the same slab, but above, is a cranidium with an *Anoria*-like facial suture and palpebral lobe. It is too large, however, to belong to the described specimen.

Types.—Holotype, U.S.N.M. No. 116348; paratypes, U.S.N.M. Nos. 116333, 116349-116350.

Formation and locality.—Arrojos formation, probably loc. 800e.

SONORASPIS GOMEZI Stoyanow, new species

Plate 14, figures 5, 6

The forms placed in this species have eight thoracic segments, as in *S. torresi,* but their facial sutures outline a long palpebral lobe, as in *Glossopleura,* and the posterior thoracic segments carry median tubercles, as in thoracic segments of *Anoria,* whereas the pygidial axis, unlike *Anoria,* not only is deprived of tubercles, but does not show any trace of segmentation. The difference from *Anoria* is enhanced also by the lack of macropleural development in the thorax.

The course of the facial suture is better indicated in the specimen illustrated in figure 6 of plate 14, the holotype. It is quite evident that in this species the two anterior segments of the thorax do not carry tubercles and that the tuberculation is restricted only to six posterior thoracic segments. It also seems that the pleural spines in the thorax are turned backward less abruptly than in *S. torresi*. The pygidial axis is rather narrow, pointed, and relatively long. Paratype, figure 5 of plate 14, has the pygidial platform better outlined and with anterior segments clearly indicated, whereas in the holotype it is smooth and barely marked off the posterior border.

Types.—Holotype, U.S.N.M. No. 116334; paratype, U.S.N.M. No. 116335.

Formation and locality.—Arrojos formation, probably loc. 800e.

AMECEPHALUS? cf. A. PIOCHENSIS (Walcott)

Plate 14, figures 7, 8

Amecephalus piochensis (WALCOTT), Smithsonian Misc. Coll., vol. 75, No. 3, p. 66, pl. 15, fig. 9, only, 1925.

Described trilobite is represented by two incomplete conspecific specimens. In one of them (pl. 14, fig. 7) a diagonal break from upper right to lower left has cut off obliquely the anterior part of the dorsal shield leaving intact the entire right side of the thorax but reducing the axis to 14, and the left side of the thorax to 12, complete segments. In the other specimen (pl. 14, fig. 8) a similar break, but running from the left side to the right, removed the preglabellar area, upper right part of the glabella, the entire right side of the cephalon, and the genal spine of the left free cheek of which only a faint impression on the matrix of the slab is observable with a magnifying glass.

The following description is made from both specimens. Dorsal shield oval save for a gradual contraction in the posterior third. Cephalon semicircular, with a wide preglabellar area and a very narrow frontal border. Fixed and free cheeks subequal. Facial suture considerably eroded but fairly visible (with a lens) below and above a small, roundly outlined palpebral lobe. Glabella tapering and lacking both occipital and glabellar furrows, though narrow posterolateral furrows are strongly indicated on the fixed cheeks.

Thorax of 16 segments with dorsal furrows subparallel down to the sixth segment but converging posteriorly. Pleural furrows close to anterior pleural margin from one-third to one-half distance from the axis whence they cut diagonally and pass into the lower margin of

pleural spines. Pleural spines progressively turned backward, becoming vertical and adpressed in the posterior segments.

Pygidium small, broad, smooth, and trilobed, with the axial lobe somewhat short of the posterior margin.

I am strongly impressed by the similarity of these trilobites to one of the forms figured by Walcott (1925, pl. 15, fig. 9) in his illustration of *Amecephalus piochensis.* However, Resser, to whom I submitted photographic pictures of the Sonora specimens, including those herein described, briefly commented (letter of March 30, 1942): "Numbers 4 to 7 all represent one species of *Alokistocare.*" What he apparently had in view was his previous removal of *Amecephalus piochensis* (Walcott) to *Alokistocare.*

In his original description of *Ptychoparia piochensis,* Walcott (1886, p. 201, pl. 26, figs. 2, *2a-b;* pl. 28, figs. 1, 1*a-e*) included nine specimens. Later (1924, p. 54) he restricted the genotype of *Am. piochensis* only to the syntypes illustrated in figure 2 of plate 26 and in figures 1 and 2 of plate 28 of the 1886 publication. In a subsequent paper (Walcott, 1925, p. 66), however, under *Am. piochensis* are listed figures 2, *2a, b* of plate 26 and figures 1, 2-2*e* of plate 28, all of the original publication. As has been mentioned above, Resser (1935, pp. 7-8) placed *Am. piochensis* in *Alokistocare* Lorenz, restricting the species to Walcott's specimens illustrated in figure 2*b* of plate 26 and in figures 1, 1*a, b, e,* of plate 28 of his 1886 description.

One of the principal characteristics of *Alokistocare subcoronatum* (Hall and Whitfield, 1877, p. 237, pl. 2, fig. 1; Walcott, 1916, pp. 182, 187), the genotype, is the presence of a preglabellar boss. Walcott (1925, p. 66) mentioned the tendency toward formation of a preglabellar boss in *Am. piochensis,* adding, however, that this is "a feature which seems to occur in a greater or less degree in nearly all trilobites with a wide frontal limb." Resser's comment on the relation between the two genera is as follows (1935, p. 8):

> Closer examination shows conclusively that it [*Am. piochensis*] is congeneric with *A. subcoronatum* and must therefore be referred to it as the older genus. Because the specimens are considerably flattened, *A. piochensis* appears somewhat different from *A. subcoronatum,* but if several specimens are carefully examined and variations due to preservation noted, generic distinctions are wanting.

Resser also regarded the entire dorsal shields of *Am. piochensis* as tapering from the cephalon to the pygidium, and pointed out that because of a lesser number of thoracic segments this feature is less pronounced in Walcott's genus. It should be noted, however, that 19 thoracic segments is the maxium indicated for both *Alokistocare* and

Amecephalus (Walcott, 1916, p. 183; 1925, p. 66), and if the axis and the entire thorax are examined separately, it is quite evident that in the latter genus only the axis tapers rapidly, whereas the entire shield contracts posteriorward gradually, which gives it a characteristically oval appearance, quite unlike the triangular posterior part in *Alokistocare*. This difference is well seen in such renowned species of *Alokistocare* as *Al. althea* Walcott (1916, pl. 25, fig. 4*a*; Resser, 1945, pl. 2, fig. 7) of which I have good topotypes, and in all illustrations of *Am. piochensis* in which the dorsal shield is preserved (Walcott, 1886, pl. 28, figs. 1*a*, 1*b*; 1924, pl. 9, fig. 1; 1925, pl. 15, fig. 9).

I should like also to point out the absence of occipital furrow in certain described specimens of *Amecephalus piochensis* (Walcott, 1886, pl. 28, fig. 1; 1924, pl. 9, fig. 1; 1925, pl. 15, figs. 8 and 9), a feature which, on the other hand, is invariably present in *Alokistocare* (Hall and Whitfield, 1877, pl. 2, fig. 1; Walcott, 1916, pl. 25, figs. 2-4*a*; Resser, 1945, pl. 22, fig. 7). Resser (1935, p. 8) mentions shallowness of the occipital furrow in his critical description of *Am. piochensis*. Two more characteristics of *Amecephalus* should be noted: the shovel-like head, which feature has been incorporated in the generic name, and the tendency of the posterior pleural spines to press against the sides of a small pygidium (Walcott, 1925, p. 66).

Walcott presented the following illustrations of *Am. piochensis* with the thorax and the pygidium preserved: two drawings, one in his paper of 1886 (pl. 28, figs. 1*a* and 1*b*. The specimens of plate 28 marked 1*b* and 1*d* have been placed by Resser under certain species of *Alokistocare*); one, a diagrammatic sketch, in the paper of 1924 (pl. 9, fig. 1); and one, and the only photographic picture with which I compare the described specimens from Sonora, in the paper of 1925 (pl. 15, fig. 9). The diagrammatic sketch, which is said to be of natural size (Walcott, 1924, p. 53), cannot be either the specimen of figure 1*a*, plate 28, 1886 (less tapering glabella and incomplete cranidium), or that of figure 9, plate 15, 1925 (no glabellar furrows). It may be an enlarged reproduction of a much smaller figure in figure 1*b*, plate 28, 1886, although there is a considerable variance in the course of facial suture.

There is an appreciable difference in the nature of the frontal border in Walcott's types, from very narrow (1886, pl. 28, fig. 1*b*; 1925, pl. 15, fig. 9) through broad to very broad (1886, pl. 28, figs. 1, 1*a*; 1924, pl. 9, fig. 1; 1925, pl. 15, figs. 8 and 10). Originally Walcott (1886, p. 202) regarded the expansion of the frontal border as a result of individual growth, but later he (Walcott, 1925, pp. 66-67) reconsidered this change in favor of relative proportions in small and large

forms. There is also a mention of a narrow, seldom-preserved rim which limits the periphery of the border. According to Resser (1935, p. 8) the broad frontal border seen in many illustrations of *Am. piochensis* is the result of a pressed doublure.

Besides the general appearance and similarity in the parts of the dorsal shield, the following characteristics are common to *Amecephalus piochensis* (Walcott, 1925, pl. 15, fig. 9 only) and the described forms from Sonora: A very narrow frontal border; lack of glabellar furrows; lack of occipital furrow; to all appearances a similar course of the facial suture; backward orientation of relatively long pleural spines which become more pressed against the body of the dorsal shield in the last segments of the thorax. There may be a slight difference in the relative width of fixed and free cheeks, and the number of thoracic segments is appreciably less in the described trilobite, only 16 against 19. Although, as mentioned above, Resser held that the number of thoracic segments is less in the types of *Amecephalus* than in *Alokistocare,* I could not find a corroboration for this statement. The smallest number, as seen in one of Walcott's illustrations (1924, pl. 9, fig. 1), is 18.

Since the Sonora specimens are few and incomplete, and because there may be more than one genus within Walcott's *Amecephalus,* as already has been interpreted by Resser, I have placed the described forms in this genus provisionally, pending the discovery and study of better-preserved material.

Hypotypes.—U.S.N.M. Nos. 116337, 116351-116352.

Formation and locality.—Arrojos formation, probably loc. 800e.

INCERTAE SEDIS

Plate 14, figure 9

In Dr. Cooper's collection there are two poorly preserved cranidia of which the better specimen is illustrated in figure 9 of plate 14.

Though the specimen is eroded and somewhat deformed, it appears that the glabella is truncated or broadly rounded in front, the occipital and posterolateral furrows are present and of narrow character, and the slightly elevated preglabellar area is strongly separated from a more elevated border by a relatively wide and deep frontal furrow. The second cranidium, not illustrated, supports these observations. It was suggested that such forms may be connected with *Inglefieldia* which was interpreted by Poulsen (1927, p. 261) as closely related to *Amecephalus,* but the nature of the occipital ring and the relation between the preglabellar area and the border seem to be sufficiently different.

Figured specimen.—U.S.N.M. No. 116337.

Formation and locality.—Arrojos formation, probably loc. 800e.

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TRILOBITES

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(Plates 15-31)

INTRODUCTION

The first Cambrian fossils reported from this region (Stoyanow, 1924) were several trilobite specimens obtained from slates in the Arrojos formation. The many collections upon which the present report is based were made by Dr. G. A. Cooper and Ing. A. R. V. Arellano during the field seasons of 1943 and 1944. Some shale specimens were obtained, but the greater part of the material comes from limestone. These are much better preserved and more satisfactory for study than the shale material.

A more exact age determination can now be made for the several formations that have furnished adequate fossil collections, and correlations with known fossil assemblages in other parts of North America can be attempted. In the Puerto Blanco formation a zone of *Obolella* shells occurs near the base, and through the upper half occurs a series of beds characterized solely by genera of the Olenellidae. The overlying Proveedora quartzite has furnished a few fragments of Olenellidae. The succeeding Buelna limestone carries a third, very fossiliferous, trilobite bed. The latter appears unquestionably to represent the *Antagmus-Onchocephalus* zone (Lochman, 1947) at the top of the Lower Cambrian. The first-mentioned zone may be correlated with an *Obolella* zone reported from near the base of the Lower Cambrian sections in southeastern United States. The highest formation assigned to the Lower Cambrian in the Mexican section, the Cerro Prieto limestone, contains only *Girvanella* "reefs."

The overlying Arrojos formation carries several faunal zones, all of Middle Cambrian age. The lower beds contain a limited fauna apparently representative of the *Albertella* zone, and about 100 feet higher appears a very fossiliferous bed characterized by a fauna best correlated with the *Glossopleura-Kootenia* zone. The few species from the shales in the upper half of Arrojos appear to belong to this zone also. All the overlying Tren dolomite is very poorly fossiliferous. The few specimens obtained from beds near the top serve only to sug-

gest that the rest of the section is also in the Middle Cambrian, and that no Upper Cambrian rocks occur in this region.

These Cambrian collections contain fossils representative of only six groups of animals: Sponges, brachiopods, trilobites; *Scenella,* an early gastropod; *Salterella,* a primitive cephalopod; and *Hyolithes.* Of these only the trilobites, brachiopods, and *Salterella* are abundant. Trilobite fossils dominate Cambrian faunas the world over. Several factors are believed responsible for this fact. The trilobite, a primitive member of the highest invertebrate phylum (Arthropoda), was one of the few animals at this time that had a protective dorsal covering impregnated with calcium carbonate and thus capable of preservation. Moreover, these coverings were shed periodically as the animal grew, thus making available for burial and preservation a large number of molts. However, paleontologists have long suspected that a normal fauna of the Cambrian sea contained not only the few types represented by the fossils, but also many soft-bodied animals possibly belonging to all the other invertebrate phyla. Proof was finally obtained in 1910 when Walcott discovered the famous fauna of the Middle Cambrian Burgess shale on Mount Stephen, British Columbia. Here, owing to a combination of unusual physical conditions at the time of deposition, an amazing number of soft-bodied Middle Cambrian marine animals had been preserved as flattened carbon films on the shale. These fossils showed that several phyla of worms, the sponges, sea-cucumbers, jellyfish, and many primitive Arthropoda, as well as the brachiopods and trilobites, were alive and abundant in the Cambrian seas.

Thus the Cambrian seaway of Sonora should be pictured as a warm, sunlit, shallow sea teeming with an abundance of primitive soft-bodied invertebrates as well as the shelled brachiopods and trilobites. In this Cambrian fauna the trilobites were probably one of the commonest and most successful groups, and certainly in their body structure were one of the most advanced types living at that time.

This paper describes the fossils that have been obtained to date from this early Cambrian seaway in northwestern Mexico. A fairly large amount of material was collected, and the 32 genera and 45 species here described furnish the first detailed information on the Cambrian of this region. However, the first work in any area should be regarded as a preliminary report. Many additional problems have been raised during this study which are now awaiting solution. They should serve as an incentive for more extensive and detailed work on the Cambrian stratigraphy and paleontology of Mexico.

STRUCTURE

The Trilobitae are a now extinct class of animals that belong to the great invertebrate phylum Arthropoda. They fulfill the basic requirement of this phylum by possessing jointed legs, a fact fortunately revealed by some rare fossils on which these soft parts are preserved (Raymond, 1920; Størmer, 1939). These appendages consist of a variable number of paired legs and one pair of antennae, all on the ventral surface. The bodies of arthropods are composed of a series of

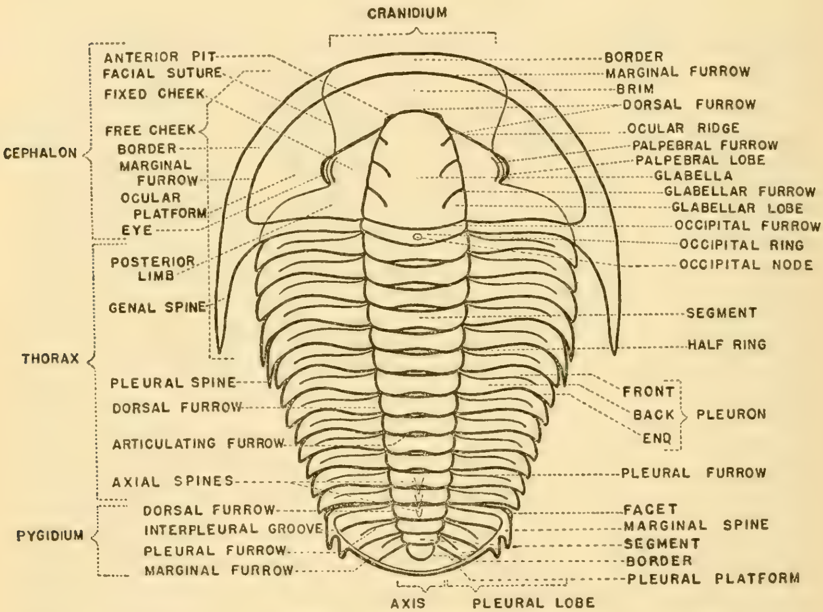

FIG. 8.—Diagram of the trilobite carapace showing nomenclature of its parts.

articulating segments which tend to fuse together particularly in the head region. This feature is not unique to the Arthropoda, as it is found in other phyla as well, but in the Arthropoda this fusion has proceeded farther than in other groups.

Figure 8 is a diagram of the complete dorsal covering, or carapace of a trilobite—the part of the animal that was composed of a horny material impregnated with calcium carbonate, and thus capable of being preserved as a fossil. This carapace apparently duplicates faithfully the segmentation of the inner soft body. In the diagram (fig. 8) all the parts of the dorsal carapace are labeled with the terms that are used in this paper. These terms were recently suggested for standard use (Howell, Frederickson, et al., 1947), and the reader is referred

to that paper for a definition of each term and synonyms of terms. Three additional features of the carapace which lie on the ventral surface, the doublure, hypostoma, and metastoma, do not appear in the diagram, but they are defined in the above-mentioned paper.

The carapace on the dorsal surface reveals a striking threefold longitudinal division of the body into a central convex axis and two lateral lower pleural lobes. This division is believed responsible for the name of the class—Trilobitae, three-lobed. The carapace also shows a threefold transverse division produced by the fusion of a number of the anterior and posterior segments of the body. These divisions consist of a head portion called the cephalon, formed of six fused segments (Størmer, 1941) and carrying the important sense organs and the mouth; a middle portion called the thorax, formed of a variable number of freely articulating segments; and a hind portion called the pygidium, composed of a variable number of fused segments and carrying the anus. In the cephalon the axial portion, the glabella, covers the enlarged part of the intestine which serves as a stomach, and probably also the digestive glands around it. The arched construction of the cephalon indicates that there was an appreciable thickness to the cephalon in the fixed and free-cheek areas. Very probably the major nerve ganglia, blood vessels, and the reproductive organs were located within these portions of the cephalon, as is the case in the living *Limulus*. Such a concentration of body organs in the cephalic region is suggested by the adult structure in the trilobites and also by the embryonic development. In the thorax and pygidium the axis covers the long, segmented abdomen, which probably contained the intestine, a dorsal blood vessel, and a ventral nerve cord. The thin pleural lobes cover and protect the appendages which are attached to the ventral surface of the abdomen and project laterally on each side (fig. 8).

The ventral surface of the trilobite is rarely preserved, because, with the exception of the doublure, hypostoma, and metastoma, it is covered only by a thin, horny ventral membrane. A similar membrane also covers the appendages. The relatively short legs of the trilobite did not lift the animal far off the sea bottom but served only to push it along over the surface. Thus in normal position the ventral surface was naturally protected, and it mattered little that the group was not able to develop a hard ventral covering. But if the trilobite were rolled over by a strong wave or some larger animal, the ventral surface was exposed and the animal was defenseless. By the Middle Cambrian the trilobites had acquired the habit of rolling up into a tight ball when disturbed. The legs were tucked inside, the front of the

cephalon met the back of the pygidium, the ends of the pleura interlocked along the sides, and the soft ventral surface was completely concealed. The value of this feature is revealed by the fact that all trilobites living after the Cambrian possessed the ability to enroll.

The structure of the trilobite appendage has always been of utmost importance to paleontologists because the classification of the modern Arthropoda is based upon the character of the legs. Through the years students have persistently worked at reconstructing and interpreting the rare finds of trilobite appendages. The reconstructions have differed and the classifications varied, some authors favoring

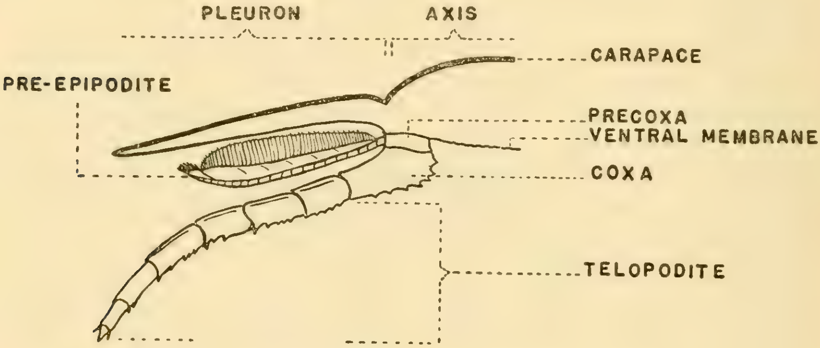

FIG. 9.—Reconstruction of the trilobite appendage.

crustacean, others arachnidan affinities. All students agree that the first pair of appendages are jointed antennae. These are followed by a long series of paired legs, the first four pairs on the cephalon being apparently exactly like those on the thorax and pygidium, except for somewhat smaller size. A row of strong bristles, the gnathobases, on the inner edge of the coxa is believed to have served to crush and tear the food and push it into the mouth. Figure 9 gives the latest reconstruction of the trilobite appendage (Størmer, 1939). The appendage consists of a walking leg (the telopodite) of a coxa and seven distal segments, and a proximal segment, the precoxa, which lies against the body. A dorsal branch (the pre-epipodite) originates on the precoxa, consists of a shaft bearing a fringe of flexible filaments, and apparently functions as a gill. There is no clear evidence of a swimming appendage. This reconstruction is considered by Størmer to indicate a close relationship between the Trilobitae and the class Arachnida. The primitive xiphosuran *Limulus* is generally believed to be the closest living relative of the trilobites.

ECOLOGY

Trilobites are believed to have been important sea-bottom scavengers of the early Paleozoic. During the Cambrian the various genera fully occupied the benthos, crawling actively over the surface, hiding in crevices on reefs, lying partially buried in the bottom sediments, or burrowing slowly through soft mud and sand. The structure of certain later Paleozoic trilobites is interpreted as indicating a semiplanktonic type of life, but there is no evidence of such specializations in the Cambrian forms. I also seriously doubt whether any Cambrian trilobites were truly nektonic, as the structure of the appendages would have made them poor swimmers at best. Moreover, the increasingly strong tendency to enroll to protect the exposed ventral surface does not fit into the nektonic habitat. All living animals using enrollment are rather sluggish benthos.

The trilobite probably crawled forward over the surface bending from side to side in a more or less sinuous manner. This body motion, inherited from the pre-Cambrian wormlike ancestor, was most noticeable in the Olenellidae and other Lower and Middle Cambrian trilobites in which the thorax was composed of many articulating segments and the pygidium was small. It must have been gradually lost as a larger fused pygidium was developed and the muscles of the thorax were changed for enrollment.

With its antennae and its legs, the trilobite explored the sea floor for dead or dying organisms. When found, these fragments were moved toward the mouth either mechanically by the legs or by water currents. They were caught and held at the mouth by the hypostoma and metastoma while the gnathobases tore or crushed them into small enough particles to be swallowed. The primitive mouth parts sharply limited the trilobites' food supply to small, soft, and inactive animals. Although the majority of Cambrian animals were apparently without hard parts, the gnathobases were probably not capable of holding an actively struggling animal.

We may risk certain postulates concerning temperature, depth, and facies adaptations among the trilobites, although it will always be difficult to obtain any positive proof of these deductions. The largest number of trilobite genera and species always occurs in a limestone facies and in such faunal assemblages as to indicate that the majority of the trilobites, like the brachiopods, favored a clear, shallow, sunlit seaway where normal marine conditions permitted slow accumulation of limy oozes. However, many Cambrian genera and species are found in beds of all three types of facies. Some, such as the Middle

Cambrian *Zacanthoides* and *Albertella,* show, apparently, a decided preference for a shaly type of facies; while others, such as the Upper Cambrian *Crepicephalus* or *Elvinia,* occur in equal abundance in all facies. In this respect the Cambrian trilobites appear to be definitely more primitive and generalized than the later Paleozoic stocks. After the Cambrian a more and more rigid specialization to one particular habitat appears to have developed in most of the surviving genera.

Concerning depth ranges we can only indirectly conclude from the facies distributions that the Cambrian trilobites certainly occupied all depths in the neritic zone. It is possible that certain genera may have penetrated to greater depths.

The cosmopolitan distribution of many Cambrian genera suggests either a ready adaptation of the trilobites to a wide range of temperatures or else a uniformity of temperature over large areas in the Cambrian. Some conclusions can be drawn from analogies with modern faunal assemblages. A fauna such as that of the *Glossopleura-Kootenia* zone, in which a variety of genera and species is represented by a moderate number of individuals, may be regarded as indicative of warm waters. As the waters become progressively cooler, the variety in the fauna becomes less. In cool-temperate to cold waters the fauna is characterized by an excessive number of individuals of a few limited genera and species. The Upper Cambrian *Aphelaspis* fauna is considered an excellent example of such a trilobite assemblage in cold waters (Lochman and Duncan, 1944).

COLLECTION AND PREPARATION OF CAMBRIAN FOSSILS

Cambrian trilobites may be found in most types of sedimentary rocks, a fact that demands the use of different techniques of collecting and preparation to fit the different facies. The trilobites from the Sonora region occur in quartzites, shales, limestones, and dolomites.

Cambrian dolomites are notorious for their lack of fossils, and the Tren dolomite at the top of the section is no exception. The best chance of obtaining fossils in such a rock is to locate, if possible, small beds or patches of limestone within the dolomite. This limestone is more likely to be fossiliferous. In the dolomite, persistent and painstaking breaking of pieces and examination of weathered surfaces may yield a fossil or two, but their discovery will be quite accidental. In the Tren dolomite only three trilobite cranidia were obtained through 1,300 feet of rock, and they were poorly preserved and distorted.

Shales yield attractive fossils, but their appearance is often deceptive. Fossils may be found on pieces exposed at the surface, but fresh

material is preferable for study. Therefore, the outcrop should be cleared to a depth of several feet until perfectly fresh shale is reached. Collecting consists simply of splitting apart the shales with a knife or hammer. Many of the Cambrian green and gray shales are soft and, in order to be transported satisfactorily, must immediately, upon collecting and while still moist, be wrapped tightly in tissue paper, and these small bundles placed in receptacles. Many of these shales crumble when left exposed. The complete trilobite carapace is most apt to be preserved in shale; hence the most interesting fossils to the lay eye are obtained from this facies. But a careful inspection of the specimen reveals that all too frequently it is nothing more than a flat mud mold of the original carapace which has been leached away. Distortion in shales is also quite common. In a few instances in fresh moist shales a thin calcite film retaining the original convexity of the carapace is present. This film is, however, so fragile that it is often broken and lost before the specimen can be wrapped. Although shale and slate specimens make striking and noticeable fossils (the first fossils discovered in this region came from slates), they are poor specimens for study as it is often impossible to determine them specifically or even generically with any degree of accuracy. The carapaces are often distorted or so flattened as to make accurate identification impossible.

A similar situation exists in the case of fossils in sandstone and quartzite. The fossils are generally fine- to medium-grained sand molds of disarticulated carapaces. The specimens do show some convexity, and distortion is relatively rare; but as most of them are internal molds of the carapace, it is hard to be sure of the true depth and width of the furrows and the actual amount of convexity as they would have occurred on the dorsal surface. Moreover, a clear-cut outline is often lacking as the edges blend into the sand grains of the matrix.

Fossils freshly broken from medium- or fine-grained limestone are by far the most valuable specimens for careful study and accurate identification. Such fossils are generally disarticulated parts of the carapace replaced by very fine-grained gray or brown calcite which has preserved accurately all details of the original surface and convexity. In the field each outcrop should be examined thoroughly both vertically and laterally by breaking apart the limestone blocks along planes parallel to the bedding. After a fossiliferous bed has been located in this manner, large pieces of the limestone can be collected to be broken and examined in detail in the laboratory.

However, not all fossils in limestone are good specimens. Many Cambrian sections of western North America contain thin-bedded

dense limestones with shaly partings. Weathering along the shale partings loosens the limestone slabs and etches out the fossils on the surface. The texture of the replacement calcite of the fossil and of the rock matrix is so nearly the same that the weathering affects both at about the same rate. By the time the slab has been loosened and the fossils exposed, the original surface and convexity of the fossil have been irreparably damaged. Cross sections reveal the slabs filled with additional specimens, but they cannot be broken from the matrix. This type of fossil is most disheartening. In the field the slabs are striking specimens usually carefully collected, but, because of the deep weathering, specific identification of the fossils is always uncertain and often impossible. The beds in the Puerto Blanco formation containing *Wanneria mexicana prima* illustrate this type of dense limestone and the preservation of the fossils in it. A considerable amount of material was brought from this horizon, but not a single freshly broken specimen could be obtained.

The cleaning and preparation in the laboratory of all types and sizes of fossils should be done under a low-power binocular (Greenough type) microscope. Small details of the texture both of the fossils and of the rock matrix must be seen and appreciated if the specimen is to be cleaned with maximum efficiency. Only a fine needle, pointed or beveled as desired, should be used for cleaning shale and sandstone specimens. The small pieces of shale or grains of sand should be individually lifted or flaked off until the fossil is completely uncovered.

The limestone specimens should receive the greatest emphasis in preparation as they furnish the maximum return for the effort made. The large blocks of limestone are broken into smaller pieces with a hammer or a wedge; the latter is preferred because the plane of breaking can be more carefully controlled. It is desirable to do most of the rock breaking, specimen examination and trimming in the laboratory because the fossils as they break out are more readily retrieved, and when large or choice specimens are broken through, the pieces can be immediately glued together. Nothing is so discouraging as to open a small field collection and find that several important pieces of a good specimen have been left on the outcrop.

The broken pieces of limestone are then examined under the microscope, and all small fossils or fossils partially covered by the matrix are indicated by a red line or circle. Each piece or specimen has an individual label noting locality, section, and horizon pasted or written on it in India ink at this time. Several short systems employing fractional or decimal numbers, or letters and numbers combined, can be used. Thus each specimen may then be handled separately without

danger of confusion. The matrix is now cleaned from the specimen with a small hand drill and a needle. The coarser drilling—working down the matrix around the specimen—is done with a 5-mm. wheel. Cleaning on the specimen should be done by working off the individual calcite crystals, always under the microscope. By the beginner only needles of varying sizes and edges should be used. With practice and experience the student can learn to flake off the calcite with a 1-mm. wheel in the hand drill, but as successful results depend entirely upon the amount of pressure applied and the feel of the break, it is not recommended for the beginner, since the drill can cut quickly into the specimen. For all finishing and detailed work, only a fine needle should be used. The preparator's finger, a piece of clay, or a coating of cellulose acetate can be used to protect already exposed parts. All broken pieces should be immediately glued in place. The author wishes to emphasize that under no circumstances should acid, no matter how weak, be used on the specimens during preparation. Any strength of acid will etch the surface and thus smooth and destroy the small details that should be observed. During cleaning the needle or drill may unavoidably slip and make a hole or scratch in the calcite of the specimen. The preparator should never try to do anything to remove this hole or scratch because such an attempt will result only in additional damage to the surrounding surface. Excess dust may be wiped off with a soft brush, but the original cleaned surface with scratches must be left untouched. It should be noted that when the specimen is whitened for study and photography, all ordinary scratches fade out and only the deepest holes and cuts are still visible. But they are preferable to the willful damaging of a good specimen by attempting to remove them.

In order to heighten detail in study or making photographs two whitening agents, ammonium chloride and magnesium oxide, may be used. These have different properties and must be handled differently for best results. For sturdy calcite specimens, magnesium oxide may be used. It gives a fine-grained, brilliant coating which does not react with the calcite and so may be left on the specimen for some time. However, it can only be removed thoroughly by vigorous brushing under water. Therefore, ammonium chloride must be used on all shale, sandstone, and delicate calcite specimens. This chemical reacts slowly with calcite and in time will damage the surface so that it should be removed from the specimen immediately after use. A gentle stream of water may be used for some, but for soft shale, friable sandstone, and delicate silicified specimens a drop or two of water or

simply blowing the coating off will suffice. On these more delicate specimens it is best to use whitening only at the time of photography.

IDENTIFICATION OF TRILOBITES

During preparation specimens which look alike may be sorted into separate groups, and the study and identification can start with making generic determinations for these groups. A closer analysis of the characteristics, aided by measurements, must now be made. Peculiarities of preservation and evidences of distortion must be noted. For the trilobites, the greater emphasis in classification is usually placed upon the cranidium. In most Lower Cambrian and many Middle Cambrian species this is the only part of the carapace available, and experience shows that the most diagnostic features of the carapace are often to be found in the cranidium.

A detailed search and careful study of the literature must be made. The student should work out a clear and accurate concept of each genus by an examination of the original description, the illustrations, and, if possible, the actual specimens of the genotype. It is often convenient to use a large card for each genus, on which is noted the original reference and the diagnostic generic characters of the genotype. Then as the literature is examined, all species referred to the genus, with their locality, stratigraphic horizon, and the original reference, may be listed on the card.

After the genus has been satisfactorily determined, the finer specific distinctions must be studied. A large suite of specimens of each species is definitely desirable. It permits a clearer and more accurate picture of the amount of individual variation within a species, and a better idea of the effects of preservation and distortion upon the carapace. It is urged that clear and definite distinctions between species be cited by each student. The laborious searching for some minute difference between two cranidia, or the off-hand erection of a new species because the material is from a new locality, add nothing to our knowledge of Cambrian paleontology or stratigraphy.

DISCUSSION OF THE FAUNAS

LOWER CAMBRIAN FAUNAS

COMPOSITION

Fossils of Lower Cambrian age have been obtained from the Puerto Blanco formation, Proveedora quartzite, and the Buelna limestone. Three stratigraphic horizons of fairly abundant fossils can be recognized. Near the base of the Puerto Blanco formation are beds con-

taining large numbers of *Obolella* shells and sporadic fragments of *Olenellus* cephala. Fragments of Olenellidae occur throughout the long series of alternating sandstones and limestones that comprise the Puerto Blanco, but identifiable specimens in abundance occur only in some of the upper limestone beds. These beds carry a new species and variety of *Wanneria* and weathered cephala possibly referrable to *Olenellus*. The Proveedora quartzite furnished a few fragmentary cephala of *Wanneria* or *Olenellus*, which are believed to belong to the same faunal assemblage as the Olenellidae of the underlying Puerto Blanco. The Buelna limestone carries another very fossiliferous horizon. It appears to represent a distinct and different faunal zone. This horizon has proved very useful in the field as a stratigraphic marker. The faunal assemblage is small in actual numbers of genera and species, but hundreds of cranidia of two species of *Onchocephalus* crowd the limestone beds. The Olenellidae are represented by the widespread western species *Olenellus truemani* Walcott and *Olenellus* (*Fremontia*) *fremonti* Walcott, a new variety of *Wanneria walcottana* (Wanner), and a new species of *Paedeumias*. Three small opisthoparian genera, *Bonnia, Antagmus,* and *Sombrerella,* also occur in this fauna.

Several reddish-yellow limestone beds at various levels throughout the Buelna limestone are crowded with the small shells of the primitive cephalopod, *Salterella*. Sporadic specimens of *Salterella* and of the presumed pteropod, *Hyolithes,* were obtained both from the Puerto Blanco and Buelna formations. From the uppermost Lower Cambrian formation, Cerro Prieto, only certain algal remains, tentatively referred to *Girvanella,* were obtained.

CORRELATION

Correlation of the Mexican faunas with those reported from other Lower Cambrian sections of North America may be attempted, but the conclusions must be regarded as tentative because of the present incomplete state of knowledge of this part of the Cambrian sequence. On the Cambrian correlation chart for North America (Howell et al., 1944) four faunal zones are listed. These are, in ascending order, *Obolella* zone, *Bonnia* zone, *Olenellus* zone, and *Syspacephalus* zone. The name of the last zone was changed (Lochman, 1947) to the *Antagmus-Onchocephalus* zone as it was subsequently found that these two genera, rather than *Syspacephalus,* are really the widespread and diagnostic forms of this assemblage. Chart 1 (this paper) gives the Lower Cambrian faunal zones now recognized by the author.

In the Mexican sections the lowest fossiliferous beds contain great numbers of *Obolella* shells. Similar concentrations of *Obolella* shells occur near the base of the Lower Cambrian in southeastern United States. This occurrence led to the tentative proposal of an *Obolella* zone, characterized by a great abundance of *Obolella* shells in association with sporadic specimens of the Olenellidae, usually *Olenellus*. The similarity in faunal composition and stratigraphic position at present suggests that this *Obolella* zone may well represent the same time unit wherever found in North America.

No indication of a *Bonnia* zone has yet been obtained either in the Mexican section or anywhere else in western North America. Its validity is still to be substantiated.

In all Lower Cambrian sections in both eastern and western North America a long series of beds occurs in which genera of the Olenellidae are the predominant and usually the sole members of the trilobite fauna. All these beds are at present lumped together and referred to the all-inclusive *Olenellus zone*. It should be understood, however, that the genus *Olenellus* is definitely not restricted to this zone in the Mexican sequence, nor probably in other Lower Cambrian sections as well. Possibly a more correct name would be the Olenellida zone, with the understanding that it referred to the time of faunal prominence of the group. The considerable stratigraphic thickness occupied by this zone, and the apparent appearance and dominance of different genera at various levels within it suggest that in the future more careful and detailed stratigraphic and faunal studies may effect a subdivision. It should be pointed out, however, that the four age divisions of the *Olenellus* fauna suggested by Walcott (1915) have yet to be substantiated in a complete Lower Cambrian section. There is no evidence of such a subdivision in the Mexican sections, especially that on the north side of Puerto Blanco, which appears to be an uninterrupted section through the Lower Cambrian. Neither *Nevadia* nor *Elliptocephala* occurs, and species of *Olenellus, Wanneria,* and *Paedeumias* occur together in the same beds. Two fragmentary cephala of *Olenellus* occur in the *Obolella* beds, and the genus is known to extend through 2,040-2,060 feet of the Lower Cambrian sequence from the base of Puerto Blanco formation to the top of the Buelna limestone. At present those beds above the *Obolella* zone in which only trilobite genera of the Olenellidae occur may be considered the time equivalent of the *Olenellus* zone.

The highest recognized faunal zone of the Lower Cambrian is characterized by the appearance and dominance of several generalized opisthoparian genera. In the Mexican sections *Olenellus, Paedeumias,*

and *Wanneria* are still present in moderate numbers. In other North American sections at this horizon sporadic specimens generally referred to *Olenellus* have usually been recorded. It is customary now to place the end of the Lower Cambrian at the time of the disappearance of the Olenellidae rather than of the rise of the Opisthoparia. The faunal assemblage of the *Antagmus-Onchocephalus* zone is characteristic of this time of transition. The occurrence of the two diagnostic genera, *Antagmus* and *Onchocephalus,* near the top of many Lower Cambrian sections in North America, suggests that the zone is widespread. At present, knowledge of the complete and characteristic faunal assemblage of this zone is lacking. The horizon of *Olenellus* and *Antagmus* in the Grand Canyon sequence (McKee and Resser, 1945), and the Mount Whyte formation of Alberta and British Columbia (Deiss, 1939, 1940) can be considered the time equivalent of the beds with this zone in the Mexican sections.

MIDDLE CAMBRIAN FAUNAS

FAUNAL ZONES

Two faunal assemblages of the early Middle Cambrian are well represented in the Mexican section, and the highest formation contains elements of a fauna of the later Middle Cambrian. Study of the Mexican sequences and a careful examination of the descriptions of other Cordilleran Middle Cambrian sections have convinced the author that errors and misconceptions are present in the early zones of the Middle Cambrian as indicated in the Cambrian correlation chart (Howell et al., 1944). The difficulty seems to have arisen from two causes. The Middle Cambrian workers have attempted to maintain the details of local sections as regional zones, and they have not fully appreciated the great influence of facies upon the appearance and abundance of certain early Middle Cambrian genera. *Albertella, Zacanthoides,* and *Anoria* are especially good examples, as they occur as quite striking fossils in a shale facies and consequently were readily noticed. The faunal zones as indicated in the Cordilleran sections measured by Wheeler (1943) and Deiss (1938, 1939, 1940) illustrate this feature very clearly.

The author believes that the earliest complete Middle Cambrian faunal assemblage is that which makes its appearance at the base of the Middle Cambrian in what is called the *Kochaspis liliana* zone and continues as a unit through the so-called *Albertella* zone. She proposes that this lowest Middle Cambrian faunal zone and faunal assemblage be known as the *Albertella* fauna, and that the entire faunal assemblage

of this zone be taken into consideration when locating it in a section (see chart 2). At present the following genera are restricted to and diagnostic of this assemblage: *Albertella, Strotocephalus, Proveedoria, Mexicella, Mexicaspis.* As the fauna is studied in more detail throughout the Cordilleran sections, it is to be expected that a more complete list of restricted genera may be established.

The term *Kochaspis liliana* zone has little if any exact value because the species is not everywhere present in these basal Middle Cambrian beds, and the genus *Kochaspis* apparently ranges through most of the Middle Cambrian. *Kochaspis* does appear in the earliest Middle Cambrian beds in many Cordilleran sections, sometimes in such abundance as to attract the immediate attention of stratigraphers; at other places in more moderate numbers associated with other trilobite genera, recognized members of the *Albertella* fauna. These genera continue to be associated together throughout what has been called the *Albertella* zone. *Albertella* itself is capable of appearing anywhere within the range of the zone as recognized by Lochman, but is a genus which, either because of original environmental preference of the living animal or some detail of preservation of the test, occurs most commonly in a shale matrix. Hundreds of shale specimens of *Albertella* have been obtained to date from this zone, but the author knows of only about 20 limestone specimens. This peculiarity has led to some confusion in the position of *Albertella,* as only when the fossils occur in abundance in the shales are they noted by stratigraphers. However, the stratigraphic position of shale beds is known to vary in the Cordilleran sections.

In two of the Mexican sections there is an indication of a transitional horizon between the characteristic assemblage of the *Albertella* zone and that of the overlying *Glossopleura-Kootenia* zone. The genera *Pachyaspis* and *Glossopleura* make their appearance in association with *Mexicella, Mexicaspis,* and *Albertella,* and continue into the succeeding beds after these three genera have disappeared. The author has drawn the arbitrary boundary line between the two zones in the Mexican sections after the disappearance of *Albertella* and *Mexicaspis.* It must be recognized, however, that there is an interval of time represented here during which the characteristic genera of the *Albertella* zone were dying out and the characteristic genera of the *Glossopleura-Kootenia* zone were migrating into the region. Thus when a collection is made from this particular horizon a truly transitional faunal assemblage will be obtained. Such a transitional assemblage is represented also by the fauna of the *Ptarmigania* strata of the Langston limestone as listed by Williams and Maxey (1941).

The Utah fauna is considered by the author as representing only the very end of the *Albertella* zone because all the characteristic genera except *Albertella* are missing, and the fauna of the immediately overlying Spence shale member is a typical *Glossopleura-Kootenia* assemblage.

The second Middle Cambrian faunal zone recognized by the author contains the faunal assemblage: *Glossopleura, Kootenia, Alokistocare, Anoria, Zacanthoides, Pachyaspis,* and *Athabaskia* (the cited *Clavaspidella* of the Cordilleran region). This assemblage and zone begin in most Cordilleran sections with the appearance of *Glossopleura* and *Alokistocare.* To date *Alokistocare* appears to be fairly widespread and somewhat more restricted in vertical range than *Glossopleura.* The latter genus, while appearing in certain sections before the arbitrary beginning of the zone, is, nevertheless, an especially important member of the assemblage. It has a long stratigraphic range through the entire zone, a wide geographic range, and a valuable impartiality toward different facies.

The author does not recognize the individual identity of a faunal zone characterized by the restricted occurrence of *Anoria* and *Zacanthoides.* These two genera, like *Albertella,* occur most commonly and conspicuously in shale beds. *Anoria* may have a somewhat limited stratigraphic range, but in four widely separated localities these two genera occur with recognized members of the *Glossopleura-Kootenia* fauna. In locality 801-O of the Puerto Blanco section, *Zacanthoides* occurs with *Alokistocare althea* (Walcott), although represented by only a few small, rare specimens, as the matrix is limestone. In the Grand Canyon section (McKee and Resser, 1945) at locality 19 *Anoria* occurs with *Glossopleura* and *Alokistocare althea* (Walcott), and at U.S.N.M. locality 11 *Zacanthoides* occurs with *Kootenia* and *Pachyaspis.* In Utah the Spence shale member of the Langston contains *Zacanthoides, Glossopleura, Alokistocare,* and other genera (Williams and Maxey, 1941). In the British Columbia sections Deiss (1939a, pp. 1017-1018) suggests that *Anoria* and *Athabaskia* are within the *Glossopleura* fauna. The association of all these genera in a single assemblage must be recognized. On chart 2 the author proposes the single faunal zone, *Glossopleura-Kootenia,* to succeed the *Albertella* zone.

No further evidence concerning Middle Cambrian faunal zones could be obtained from the Mexican sections, as the highest formation, the nearly 2,000-foot Tren dolomite, is almost entirely unfossiliferous. Three fragmentary cranidia were obtained from it, and two of them were tentatively referred to *Parehmania.* This genus is a member of

the *Elrathia* stock which becomes prominent in the later half of the Middle Cambrian. It is considered indicative of the presence of the *Elrathiella-Clappaspis* zone (Howell et al., 1944), but no details of the fauna of this zone can be contributed from the Mexican sections. In this connection it should be mentioned that the species referred to *Ehmaniella* from the *Ptarmigania* fauna (Resser, 1939) and most of the species referred to *Parehmania, Ehmania, Elrathia,* and *Elrathiella* from the Grand Canyon sections (McKee and Resser, 1945) do not appear to belong to those genera as defined. They were all examined in the course of this study as it was assumed that there should be some faunal connections between the two regions. A careful revision of the Grand Canyon generic identifications should be made before the faunal lists can be used accurately for correlation purposes.

COMPOSITION

The genera of the *Albertella* faunal assemblage in the Mexican sections are: *Kochaspis, Strotocephalus, Albertella, Proveedoria, Mexicella, Mexicaspis,* and *Ptarmigania.* Of these, *Kochaspis* has such a long stratigraphic range as to be unimportant except for the fact that, as usual, it makes its appearance in the earliest recognized Middle Cambrian fauna. *Albertella* is the guide fossil for the zone. *Mexicaspis* is closely related to *Albertella,* and well represented by individuals of two species. It will be interesting to watch future discoveries of *Mexicaspis* to see if it is a southern variant of the *Albertella* stock. It seems much more prominent than *Albertella,* but as the Mexican section is largely limestone at this horizon, it is not possible to draw any definite conclusions from poor representation of *Albertella* in these sections. *Strotocephalus* was previously recognized only from the *Albertella* fauna of the Gordon formation of Montana (Deiss, 1939, p. 38). The genus *Mexicella* will probably prove to be one of the most valuable guide fossils of this zone. It was established for the old "*Agraulos stator* Walcott," more recently "*Alokistocare stator* (Walcott)," which occurs so abundantly in the Ross Lake shale member of the Cathedral dolomite (Deiss, 1939a, p. 1004), and also occurs in a sandstone from Montana. A closely related species occurs abundantly in the Mexican sections. Apparently the individuals of *Mexicella* had no facies preference. The occurrence of a few specimens of *Ptarmigania* in locality 801j, approximately in the middle of the *Albertella* zone, and in association with *Mexicella,* extends the stratigraphic range of this genus down at least to this position. It is possible that *Ptarmigania* may be another genus limited to and diagnostic of the

Albertella zone. Apparently its highest known occurrence is in the *Ptarmigania* fauna of Utah and Idaho. It is listed (Williams and Maxey, 1941) as being restricted to this horizon and not occurring in the immediately overlying, closely related *Glossopleura-Kootenia* faunal assemblage of the Spence shale member. Two other genera, *Glossopleura* and *Pachyaspis,* make their appearance near the top of the *Albertella* zone in the Mexican sections. Their significance is mentioned below.

During this discussion of faunas several comparisons with the Middle Cambrian faunas of the Canadian Rockies and Montana have already been made and more will be made in discussing later faunas. In order to avoid misunderstanding, it should be definitely stated that the making of comparisons with northwestern Cordilleran areas does not necessarily indicate that the Mexican sections are most closely related faunally to that region. The necessity of making such comparisons is caused by the fact that only from that region (with the exception of the Grand Canyon sections) have the early Middle Cambrian faunas been even partially described. In the case of the Grand Canyon region some comparisons can be made, but more detailed comparisons are hampered by the rather incomplete faunal representation from that region.

The genera of the *Glossopleura-Kootenia* assemblage found in the Mexican sections are fortunately many of the common, distinctive, and wide-ranging genera of this zone: *Glossopleura, Pachyaspis, Athabaskia, Zacanthoides, Kootenia, Alokistocare,* and *Alokistocarella. Inglefieldia, Kistocare,* and *Arellanella* are also present. In several sections *Glossopleura* and *Pachyaspis,* having first appeared at the top of the *Albertella* zone, continue on after the disappearance of all *Albertella* zone genera, and together constitute a very early subfaunule before the appearance of the rest of the *Glossopleura-Kootenia* assemblage. Besides the two above-mentioned genera, *Kootenia, Athabaskia, Alokistocare, Alokistocarella,* and the related zone genus *Kistocare* appear to be widespread, valuable guide fossils for this zone in all types of facies. *Kistocare tontoensis* (Resser) is now known both from the Grand Canyon region and the Mexican sections. *Zacanthoides* can only be expected in noticeable abundance when shale is present. *Anoria* does not appear in the Mexican sections, though its occurrence in the shales and sandstones of the Grand Canyon region suggests that it could range this far south. *Arellanella* has not been noted in any previously described fauna. Its close affinities to *Pachyaspis* are probably significant. *Inglefieldia* at present has little stratigraphic value, as the only valid species recorded to date are, in the

author's opinion, those from the Cape Kent formation of Greenland and the Mexican species. The single small cranidium identified by Resser as *Inglefieldia idahoensis* from the Langston is clearly a species of *Alokistocare.*

Brief mention should be made at this time of the stratigraphic status of *Kootenia.* Both the zone and faunal assemblage are called *Glossopleura-Kootenia,* and in the Cordilleran sections the appearance and abundance of *Kootenia* are undeniably a valuable aid in recognizing this zone. Yet a tabulation of the various species referred to this genus shows a reported stratigraphic range from the Lower Cambrian nearly to the end of the Middle Cambrian. Two factors seem to be responsible for some, and possibly all, of this confusion. One factor is known to be misidentification of the pygidia, the part most frequently found, with the pygidia of *Olenoides,* a late Middle Cambrian genus. An example is *Kootenia tetonensis* (Miller), so placed by Resser, which is really an *Olenoides.* While this specimen is well-enough preserved that its true identification can be made, many stratigraphers have attempted to assign fragments of pygidia to one or the other genus. Because of the general similarity of pygidia of the two genera, the author does not believe that accurate identification can be made on such fragments. A second factor is the need for a recognition of finer subgeneric distinctions within the genus itself. All the recorded Lower Cambrian specimens are from the Appalachian trough, and, as recently noted by Rasetti (1948), the pygidia of these species always have seven pairs of marginal spines, whereas no Middle Cambrian species is known with more than six pairs. It thus appears that at least in the Cordilleran region the genus *Kootenia* has some stratigraphic value.

Little can be said about the faunal assemblage of the *Elrathiella-Clappaspis* zone as found in the Tren dolomite because only the genus *Parehmania* has been tentatively recognized. This genus was described by Deiss (1939) from what was called by him the *Elrathia-Elrathina* zone in the Pentagon shale. It has since been identified from several other Cordilleran sections, but most of these assignments are incorrect and cannot be depended upon for stratigraphic conclusions.

CORRELATION

The Puerto Blanco section is regarded by the author as the most complete and the only unbroken Middle Cambrian sequence in this region. The faunal succession, as revealed by the collections from this section, indicates that the Arrojos formation is apparently the time equivalent of all the early Middle Cambrian, and the Tren dolomite is

the equivalent of at least the lower half of the later Middle Cambrian.

The lowest Middle Cambrian fauna obtained from this section contains *Strotocephalus* and *Kochaspis*. The beds with these fossils occur just above the top of the Cerro Prieto limestone, the position at which the Lower–Middle Cambrian boundary was drawn on lithologic evidence. There is no indication in this section of any bed or beds carrying an abundance of *Kochaspis liliana* (Walcott). If such a bed were very thin, it might possibly have been covered. The succeeding collections from localities 801i, 801j, 801k, 801ka, and 801L all carry

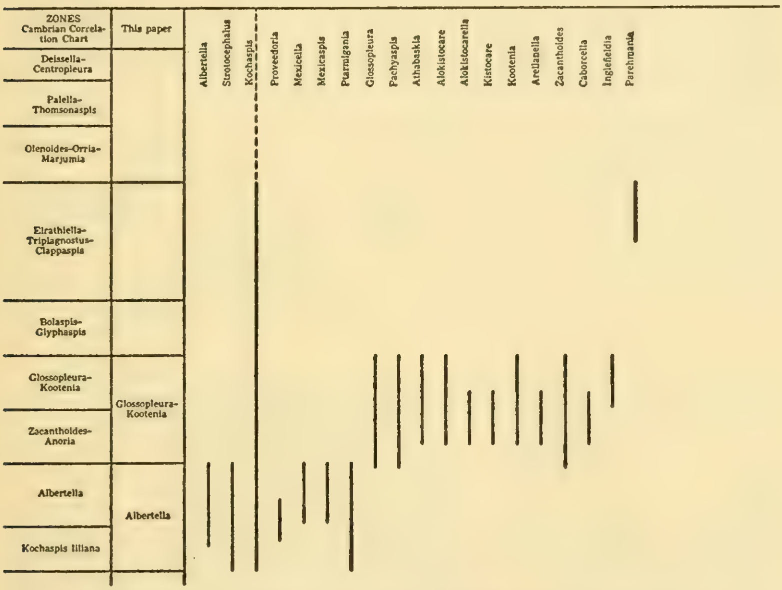

CHART I.—Correlation of Mexican Cambrian formations.

genera that are typical of the *Albertella* zone. *Kochaspis* also continues to be present. All the beds from the base of the Arrojos formation through 801L are considered to belong to one faunal zone, the *Albertella* zone. An examination of the Cambrian correlation chart (Howell et al., 1944) will give a general idea of North American correlation. On chart I a few of the more important and exact correlations in the Cordilleran region are shown. The lower part of the Arrojos formation can confidently be correlated with the lower half of the Bright Angel shale of the Grand Canyon region, the lower part of the Gordon shale of Montana, and the Ptarmigan formation and lower part of the Cathedral dolomite of British Columbia.

Collections from localities 801m, 801n, and 801-O of the Arrojos for-

mation all are representative of the *Glossopleura-Kootenia* zone, as indicated on chart 2 and discussed on page 77, the range of the common genera of this part of the section indicates that we are dealing with a single faunal assemblage of which *Zacanthoides* and *Anoria* are regular members. In chart 2 only the Mexican genera are tabulated, but a consideration of the genera of the Spence shale member alone would nearly double the genera of the assemblage. This assemblage will probably become known as one of the richest and most widely distributed of Middle Cambrian faunas when more complete studies in the Cordilleran region have been made. All evidence to

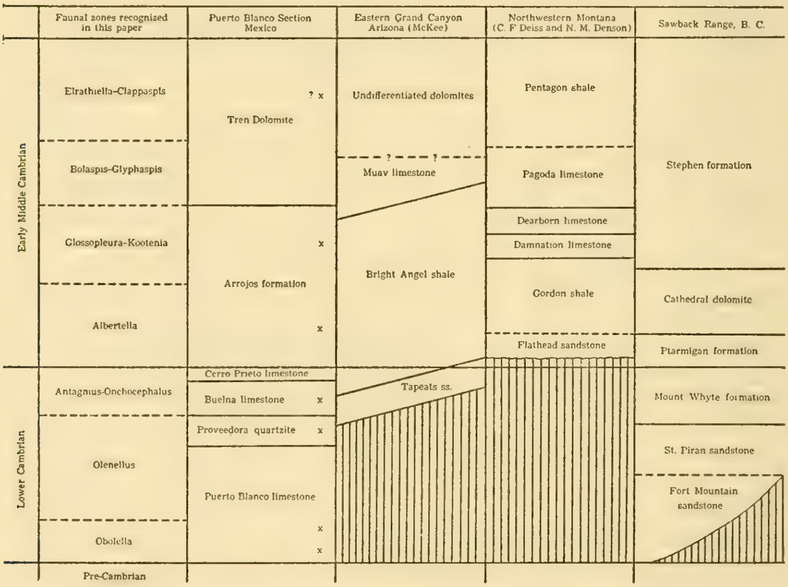

CHART 2.—Known stratigraphic range of Mexican Middle Cambrian trilobite genera.

date, with one exception (McKee and Resser, 1945), indicates that *Zacanthoides* is a normal member of the *Glossopleura-Kootenia* fauna. This exception is the occurrence of *Zacanthoides* cf. *Z. walapai* Resser at locality 40, in the Bright Angel shale, 34 feet above the Tapeats transition beds. This position would place it down in the *Albertella* zone, and has not yet been satisfactorily explained as the specimen cannot be found at the United States National Museum. The upper part of the Arrojos formation with the *Glossopleura-Kootenia* faunal assemblage is correlated with the upper part of the Bright Angel shale and a lower portion of the Muav limestone of the Grand Canyon, the highest part of the Gordon shale, the Dam-

nation and the Dearborn limestones of Montana, and the lower part of the Stephen formation of British Columbia.

The Tren dolomite consists of nearly 2,000 feet of beds from which only three poorly preserved cranidia were obtained near the top of the formation. This portion of the Middle Cambrian Mexican section occurs in the Arrojos Hills section which is very much disturbed in the lower half as indicated by the collection from locality 800d of the *Albertella* zone overlying beds carrying a diagnostic assemblage of the *Glossopleura-Kootenia* zone, and being in turn overlain by beds with the same faunal assemblage of the *Glossopleura-Kootenia* zone. However, the uppermost beds of the Arrojos formation and the overlying Tren dolomite appear to be an undisturbed sequence. The tentative identification of *Parehmania* for two of the cranidia affords a possible correlation with the *Elrathiella-Clappaspis* zone. There is no evidence of the intervening *Bolaspis-Glyphaspis* zone, but its presence in the lower portion of the Tren dolomite is quite possible. It is likewise impossible to say whether the rest of the Middle Cambrian time equivalent above the *Elrathiella-Clappaspis* zone is present in the Mexican sections. Present indirect evidence suggests that all the latest Middle Cambrian is missing from this region.

SYSTEMATIC DESCRIPTIONS

LOWER CAMBRIAN FAUNAS

PROBLEMATICA I AND II

Plate 15, figures 1-3

Two poorly preserved cone-shaped specimens occur in collection 801b in the *Olenellus* zone assemblage. The specimens might tentatively be referred to an early cap-shaped gastropod except that the poor preservation leads to considerable uncertainty concerning many of the features. One of the specimens appears to have shell fragments adhering to the internal mold which have medium-sized puncta on the inner shell surface. Another difficulty arises from the fact that the preservation is so poor that a distinct outer edge or aperture cannot be determined. As it is impossible to be sure whether these specimens truly belong to any known phylum of animals, or even whether they both represent the same phylum, they have been left unnamed but are figured for stratigraphic reference.

Figured specimens.—Internal mold with shell fragments, U.S.N.M. No. 115660; worn and crushed shell, U.S.N.M. No. 115661.

Formation and locality.—Lower Cambrian, Puerto Blanco formation, 801b.

POSITION UNCERTAIN

HYOLITHES aff. H. PRINCEPS Billings

Plate 15, figures 9-13

Hyolithes princeps BILLINGS, Can. Nat., n.s., vol. 6, p. 216, figs. 4a, b of page 213, 1872.

Hyolithes princeps Billings, WALCOTT, Bull. U. S. Geol. Surv., vol. 30, p. 135, pl. 13, figs. 5, 5a, b, 1886.

Hyolithes princeps Billings, WALCOTT, 10th Ann. Rep. U. S. Geol. Surv., p. 261, pl. 76, figs. 1, 1a-l, 1890.

Original description.—"Shell large, sometimes attaining a length of three or four inches, tapering at the rate of about three lines to the inch. In perfectly symmetrical specimens, the transverse section is nearly a semicircle, the ventral (dorsal) side being almost flat, usually with a slight convexity, and the sides and the dorsum (ventrum) uniformly rounded. In many of the individuals, however, one side is more abruptly rounded than the other, in consequence of which the median line of the dorsum (ventrum) is not directly over that of the ventral (dorsal) side, and the specimen seems distorted. This is not the result of pressure, but is the original form of the shell. Sometimes, also, there is a rounded groove along the median line of the dorsum (ventrum). The latter is somewhat more narrowly rounded than the sides. Lower (upper) lip uniformly convex and projecting about three lines in a large specimen. Surface with fine striae and small subimbricating ridges of growth. These curve forward on the ventral (dorsal) side. In passing upwards on the sides, they at first slope backwards from the ventral (dorsal) edge, and then turn upwards and pass over the dorsum (ventrum) at a right angle to the length.

"When the width of the aperture is seven lines, the depth is about five. The operculum has not been identified."

Discussion.—A number of specimens of *Hyolithes* from two different localities have been tentatively assigned to this species. Unfortunately, all the material is in a poor state of preservation so that none of the details of the outer surface can be determined in any of the specimens, nor is it possible to determine whether any of the Mexican specimens have the curved apical tip as in the types. The identification is based particularly on the large size, the character of the transverse section which is exactly like that shown for *H. princeps* Billings, and the apical angle which averages about 15°.

Walcott also identified this species from the *Olenellus* zone in the Silver Peak group of Nevada. These specimens, in the author's opinion, surely represent the same species as the Mexican ones, but their

preservation is also too poor to justify the erection of a new species. It should be noted that this large *Hyolithes* appears to occupy about the same stratigraphic position at all three localities.

The specimens consist of one 6-inch weathered slab from locality 801b which consists entirely of *Hyolithes* shells of all sizes. The slab is a very deeply weathered limestone. In this, pieces of shells up to 50 mm. (2 inches) in length can be seen, and transverse sections up to 15 mm. across. Also from locality 801b a number of large but very fragmentary shells have been etched out of limestone. This material is interesting because the shells were covered with a sandy lime ooze which was deposited in very fine cross-bedded laminae. This material sifted into the shell and filled the interior at various angles. Subsequently the original shell material was lost, and this laminated sandy material now forms the fossil specimen. A single piece of fresh limestone from locality 801q′ was sectioned, and shows on its surface a number of *Hyolithes* tubes. These are smaller (30 mm. in length) than the others, but appear to have a similar transverse section and are thus tentatively placed here.

Figured specimens.—Large etched specimens, U.S.N.M. Nos. 115664, 115665, 115666a; sections in weathered slab, U.S.N.M. No. 115667.

Formation and locality.—Lower Cambrian, Puerto Blanco formation, 801b; Lower Cambrian, 801q′.

HYOLITHES WHITEI Resser

Plate 16, figures 2-6

Hyolithes primordialis? (Hall) White, Geogr. Geol. Expl. Surv. West 100th Merid., Preliminary Report Invertebrate Fossils, p. 6, 1874; idem, vol. 4, pt. 1, p. 37, pl. 1, figs. 5a-e, 1875.

Hyolithes billingsi Walcott (part), Bull. U. S. Geol. Surv., vol. 30, p. 134, pl. 13, figs. 1, 1a-d, 1886; 10th Ann. Rep. U. S. Geol. Surv., p. 620, pl. 75, figs. 1, 1a-d, 1890.—Lesley (part), Geol. Surv. Pennsylvania, Rep. P4, p. 294, figs., 1889.—Grabau and Shimer, North Amer. Index Foss., vol. 2, figs. 1211e-g, 1910.

Hyolithes whitei Resser, Smithsonian Misc. Coll., vol. 97, No. 10, p. 21, 1938.

Original description.— "*H. whitei* is a rather small species with a thick shell. The posterior side is nearly flat; the anterior is angular giving the tube a nearly equilateral triangular outline. The lateral corners are rounded."

Discussion.—Four specimens are tentatively referred to this species. They consist of a very poorly preserved internal mold from one locality and four specimens from a second locality. From among the

latter are two showing a well-preserved outer surface with growth lines and on one the suggestion of two equally spaced longitudinal grooves. The other two are internal molds, one of which has been partially freed from the matrix to show the typically triangular outline. However, it should be noted that neither in *H. whitei* types nor in these specimens does the transverse section form a true equilateral triangle, because by actual measurement the dorsoventral diameter is approximately one-half (a little over) the length of the dorsal side. The lateral angles on the freed internal mold are fairly sharp, but on the more weathered specimen from horizon 809a they are quite rounded. The edge of the dorsal aperture rises 1-2 mm. above the level of the side and ventral margins. The apical angle appears to be about 15° to 17°.

Hypotypes.—Three well-preserved specimens (807b), U.S.N.M. Nos. 115670, 115671a,b; weathered shell (809a), U.S.N.M. No. 115669.

Formation and locality.—Lower Cambrian, Buelna formation, 807b, 809a.

ORTHOTHECA BUELNA Lochman, new species

Plate 15, figures 4, 5

Shell a narrow conical tube, averaging 18-19 mm. in length by 3 mm. in width at the aperture; tapering to a sharp point at apex; apical angle 8°; transverse section perfectly circular with aperture a smooth horizontal circle; internal mold marked by closely spaced, fine concentric grooves, all approximately of the same strength, and very faint thin longitudinal lines running the length of the shell.

Discussion.—This species is represented by two specimens, both internal limestone molds, lying close together on the same piece of rock. They have been referred to *Orthotheca* rather than *Hyolithes* because of their apparently circular cross section, more tapered shape, and horizontal aperture. They cannot, however, be identified with any of the described species of *Orthotheca* from the Lower Cambrian, all of which occur in the Atlantic Province. These species differ from *O. buelna* in their less-tapered shape and much smaller apical angle.

Types.—Holotype, U.S.N.M. No.115662a; paratype, U.S.N.M. No. 115662b.

Formation and locality.—Lower Cambrian, Buelna formation, 807b.

Phylum MOLLUSCA

Class GASTROPODA

SCENELLA cf. S. RETICULATA Billings

Plate 15, figures 6-8

A single specimen of a young *Scenella* was found in collection from locality 809a associated with an *Antagmus-Onchocephalus* faunal assemblage. The shell is a small oval cone, with a well-defined aperture, but with the apex of the cone broken and the surface worn so that the concentric rugae and radiating lirae are only faintly suggested. The shape, size, and aperture definitely indicate a juvenile specimen of *Scenella* but an accurate specific determination does not seem possible with this limited material.

Figured specimen.—Juvenile shell, U.S.N.M. No. 115663.

Formation and locality.—Lower Cambrian, Buelna formation, 809a.

Class CEPHALOPODA

SALTERELLA MEXICANA Lochman, new species

Plate 15, figure 14; plate 16, figures 7-11; plate 17, figures 1-5

Shell a small, sharply pointed, perfectly straight cone; the largest complete specimen measuring 8 mm. in length by 2 mm. in width at aperture; most shells average 6 mm. by 1.8 mm. Cross section of shell circular from the apex to the aperture, which is perfectly circular, smooth and horizontal. Apical angle approximately 16°.

Outer surface covered with fine concentric grooves alternating with narrow concentric ridges, which are about two to three times the width of the fine grooves; in the larger shells certain of the concentric grooves about every .25 mm. appear to be slightly deeper, especially near the aperture. The markings appear to be in the nature of growth markings, each ridge marking the addition of a new internal cone. Outer shell layer very thin.

Siphuncle central, small, with circular cross section, wall complete, diameter about one-fourth width of shell measured at bottom of living chamber. Septa thin, steeply inverted cones, arranged very close together, the space between each septum being approximately the same as the width of the septum; living chamber occupying almost but not quite one-half the length of the shell.

Discussion.—The specimens representing this species occur in very large numbers at several localities and several horizons throughout the *Olenellus* zone. According to the kind of preservation, several different

aspects of the shells are presented and these have been very useful in elucidating the structure. Those with well-preserved exterior surfaces present the annulated appearance as described above, while many weathered specimens appear to be quite smooth. The well-known cone-in-cone effect, from which *Salterella rugosa* Billings derived its name, is clearly caused by the removal of the outer shell layer and the exposure of the internal septal structure. Frequently the siphuncle and living chamber have been filled with extraneous material so that on weathered surfaces this internal mold and the hollow external mold are all that remain. In another type of weathering a longitudinal section is produced which shows a single cone within the shell. This appears to the author to be the wall of the living chamber that has been replaced by calcite. The best specimens for study are some artificial sections made at all angles, simply by cutting pieces of the rock containing innumerable specimens. In most of these sections the siphuncle and living chamber show up very well, but the numerous septa are less common in occurrence, as in many specimens they appear to have been subsequently replaced entirely by a crystalline calcite, which shows little or no structure.

This species is similar to *Salterella rugosa* Billings of which only weathered cone-in-cone interiors are known. Poulsen referred the extremely abundant specimens from Greenland to Billings's species and from his Greenland specimens described the internal structures of siphuncle and septa. The discovery of the Mexican specimens indicates that Billings's types from Anse du Loup, Canada, do not show any features of real specific significance, as weathered specimens from all three localities will show the same cone-in-cone effect. Poulsen reports the exterior surface of his specimens to be smooth, but, unfortunately, the exterior is not known of any of Billings's types. Certainly the Mexican specimens show distinct differences as compared to the Greenland specimens: (1) Concentric grooves and ridges on the exterior surface; (2) the living chamber is much larger, nearly one-half the length of the shell as compared to one-third to two-fifths; (3) the septa are thin, closely packed, and show no branching at the outer walls; (4) the siphuncle is a definite tube wider in proportion to the width of the shell. At present no certainty exists as to whether the types of *Salterella rugosa* Billings have an internal structure like that of the Mexican specimens or the Greenland specimens, so actually doubt must remain as to the specific assignment of both these species.

The Mexican species can be definitely said to show no real relationship to *Salterella expansa* Poulsen or *S. conulata* Clark, if the internal

structure given for these species is correct. Nor does it show any striking similarity to the primitive orthoceroid and hyolithid internal structure as depicted by Kobayashi (1937).

The shell coquinas which the Mexican specimens form suggest accumulation of the shells by wave action. In nearly all collections the *Salterella* shells occur in separate beds, and only at locality 807b do they occur mixed with trilobite carapaces. Otherwise, while the *Salterella* coquinas may be interbedded with trilobite-bearing limestone, the two types of beds are generally mutually exclusive.

Types.—Holotype, small section showing septa and siphuncle (807g), U.S.N.M. No. 115677a; paratype: sections showing living chamber and siphuncle (807g), U.S.N.M. No. 115677b; piece showing longitudinal and transverse sections with many septa (807g), U.S.N.M. Nos. 115674a-c; specimens with external ornamentation (809a), U.S.N.M. Nos. 115675a, 115678; specimens showing weathered cone-within-cone effect (807b), U.S.N.M. Nos. 115672a, 115673a; specimens showing internal mold of living chamber and siphuncle and external mold of shell (801t), U.S.N.M. No. 115676.

Formation and locality.— Lower Cambrian, Buelna formation, 807, 807f, 807g, 809a, 809d, 801t; Puerto Blanco formation, 801q.

SALTERELLA cf. S. PULCHELLA Billings

Plate 16, figure 1

Salterella pulchella Billings, Geology of Vermont, vol. 2, p. 955, 1861; Pal. Foss., vol. 1, p. 18, 1865.—Walcott, Bull. U. S. Geol. Surv., vol. 30, p. 144, pl. 13, figs. 3, 3a, pl. 8, figs. 7, 7a, 1886; 10th Ann. Rep. U. S. Geol. Surv., p. 625, pl. 79, figs. 5, 5a-e, 1890.

Original description.—"Elongate, conical, gently curved, from six to eight lines in length and from one to one and a half in width at the aperture. Surface ornamented with small encircling striae just visible to the naked eye.

"This species is larger than *S. rugosa,* always a little curved, not so abundant, and when weathered does not present the sharp imbricating annulations of that species."

Discussion.—A single shell occurs among the innumerable specimens of *Salterella mexicana,* new species, which shows a slight curvature instead of the perfectly straight cone. It has the exterior surface preserved, and shows the same fine concentric grooves alternating with concentric ridges. It measures approximately 7 mm. in length, and is thus comparable in size to the specimens of *Salterella mexicana.* In

view of the rareness of this form, the author suspects that the curvature may be either a feature of preservation or an unusual individual variation. It should be noted that the examples of *Salterella pulchella* Billings were recorded by Billings as occurring with his specimens of *Salterella rugosa* but being fewer in number.

Hypotype.—U.S.N.M. No. 115668.

Formation and locality.—Lower Cambrian, Buelna formation, 809a.

SALTERELLA, species undetermined

Plate 17, figures 6, 7

Two pieces of limestone from different localities have, because of their preservation, been so identified. It is considered highly probable that they represent the same species as *S. mexicana* Lochman, as they agree with that species in general size and shape. However, their preservation is poor and positive specific identification really cannot be made. One piece is a highly baked limestone which contains on its weathered surface several sections of *Salterella;* one shows a single cone within the shell which is interpreted by the author as being the wall of the living chamber replaced by calcite. This specimen is from locality 812a.

The second piece of rock is a small weathered limestone slab which was picked up loose on the slope west of the saddle in the Puerto Blanco section in such a position that it must come from the lower part of the Middle Cambrian just above the Cerro Prieto limestone. In spite of the weathered condition, it is clearly a *Salterella.*

Figured specimens.—Sections in metamorphosed limestone (812a), U.S.N.M. No.115680; section in weathered limestone, U.S.N.M. No. 115679.

Formation and locality.—Lower Cambrian, 812a, and loose on slope on west side of Cerro Prieto limestone ridge and saddle between highest hills, Proveedora Hills.

Phylum ARTHROPODA

Class TRILOBITAE

Family OLENELLIDAE Vogdes, 1893

Genus OLENELLUS Hall, 1862

OLENELLUS (OLENELLUS) TRUEMANI Walcott

Plate 18, figures 6-12

Olenellus truemani WALCOTT, Smithsonian Misc. Coll., vol. 57, No. 11, p. 316, 1913.

Original description.—"This species differs from *Olenellus thompsoni* (Hall) and *O. gilberti* Meek in having shorter palpebral lobes and eyes, smaller and shorter plural [sic] lobes of the third thoracic segment, and in having a more coarsely reticulated outer surface of the test, in the latter character resembling *O. reticulatus* Peach. It differs from the latter and *O. lapworthi* Peach in having a stronger rim about the cephalon, the anterior glabellar lobe closer to the frontal rim, and a broader thorax and smaller, shorter pleural lobe on the third segment. The third thoracic segment is distinctly larger than the others in all specimens; proportionally it decreases in size from the young to the largest adults . . . .

"The hypostoma has a denticulated posterior margin similar to that of *Paedeumias transitans* and *Wanneria halli.* It appears to have been attached to the doublure by its anterior margin and not by a process as in *Paedeumias transitans.*

"The specimens of this species are abundant and usually well preserved. The largest cephalon collected had a width of 50 mm. and a length of 22 mm., and the entire dorsal shield has a length of 56 mm. exclusive of the spine-like telson."

Supplementary description.—Cephalon semicircular, moderately convex in profile; glabella slightly hourglass-shaped; first, or anterior lobe, moderately convex, vertical in front, broadest at base of palpebral lobes, tapering inward to rounded front; second lobe wide, increasing in length at sides which are bent backward; third lobe shorter, chevron-shaped; fourth lobe longer and wider, chevron-shaped; occipital ring same size as fourth lobe, with small median posterior node. First glabellar furrow broad and faint across base of palpebral lobes, then more distinct and sharply curved; second glabellar furrow very faint under bent ends, then deepening into diagonal slits, and disappearing along median line; third glabellar furrow straight, diagonal, well defined laterally, nearly obsolete on median line; occipital furrow

straight, diagonal, deep at sides, nearly obsolete across middle; dorsal furrow present posterior to third glabellar furrow, then absent, reappearing faintly around front of anterior lobe. Palpebral lobes strong, slightly arcuate, running from base of anterior lobe to very slightly posterior to occipital furrow; palpebral furrow well defined in front, faint posterior. Eye vertical, apparently extending full length of lobe. Fixed-cheek area small, slanting upward from dorsal furrow to palpebral furrow except end of eye where slope is downward to posterior marginal furrow. Free-cheek area of medium width, increasing posteriorly from a narrow, flat brim; marginal furrow narrow, continuous around cephalon; marginal border narrow, convex, rimlike, with short slender genal spines; a faint posterior facial suture ridge running from base of eye out laterally, then curving back to posterior margin two-thirds of length out from dorsal furrow; in immature cephala this length is one-half and a small intergenal spine is present at this position.

Thorax with 15 segments having small axial nodes on 7 to 14 and large spine on fifteenth; segments broad and flat with a broad, shallow pleural furrow; falcate terminations of second and third progressively enlarged.

Pygidium not observed.

Outer surface of immature cephala finely granulated; of mature cephala covered by fine interrupted wavy ridges conforming to contours of cephalon; inner surface of free cheek covered with heavy radiating, anastomosing ridges, with one especially heavy one two-thirds of the way back on eye running outward and branching once (this heavier ridge is of common occurrence on the Olenellidae and is a feature which early authors frequently mistook for a trace of the posterior facial suture).

Discussion.—The Mexican material referred to this species consists of several nearly complete adult cephala, a number of fragments of cephala and some complete immature cephala. The immature cephala have the preglabellar area wider, the anterior glabellar lobe slightly wider and the position of the intergenal spines different as compared to the adult cephala. However, these three features appear to be characters of immaturity. These cephala are referred to the Canadian species after the following considerations. *O. truemani* Walcott is established upon the cotypes U.S.N.M. Nos. 60084-60091, all of them preserved flattened in a fine black shale, and some of the specimens obviously distorted. As a result the Mexican and Canadian specimens cannot be compared as to convexity. Of the cotypes, U.S.N.M. No. 60089 (Walcott 1913, pl. 54, fig. 8) although flattened, has a

cephalon, 7 mm. in length, which agrees in every specific detail with that of the Mexican adult. Also the larger cephalon, U.S.N.M. No. 60087 (Walcott 1913, pl. 54, fig. 6), although both crushed and distorted, has the same narrow anterior glabellar lobe and very narrow brim. But the other specimens, U.S.N.M. No. 60084, which are both interior impressions, and U.S.N.M. No.60088, a crushed dorsal view, show the anterior glabellar lobe as appearing wider and reaching to the marginal furrow. After consideration of all these specimens the author has concluded that the discrepancies in the last two mentioned are features of the shale preservation and that the first two cotypes which are conspecific with the Mexican cephalon represent the true specific features of *O. truemani* Walcott. It is interesting to note that on the same piece of shale with the complete thorax, U.S.N.M. No. 60089, a number of smaller cephala occur which are like those referred to the Mexican form, the smallest of them preserving the small intergenal spines in the one-half length position.

Hypotypes.—U.S.N.M. Nos. 115687, 115689, 115690a,b, 115691, 115692.

Formation and locality.—Lower Cambrian, Buelna formation, 807b, 807c, 807e.

OLENELLUS (FREMONTIA) FREMONTI Walcott

Plate 18, figures 4, 5

Olenellus fremonti Walcott, Smithsonian Misc. Coll., vol. 53, No. 6, p. 320, 1910 (see for complete previous synonomy).

Mesonacis fremonti (Walcott), Smithsonian Misc. Coll., vol. 81, No. 2, pp. 6-7, 1928.

Olenellus (*Fremontia*) *fremonti* Walcott, Raw, Quart. Journ. Geol. Soc. London, vol. 92, p. 243, 1936.

Original description.—"The cephalon of *O. fremonti* differs from that of *O. gilberti:* (a) in having a more expanded anterior glabella close to the rounded frontal border; (b) in having a shorter palpebral lobe, both in the young and the adult; and (c) in having an unusually expanded pleural lobe to the third thoracic segment. A comparison of the young cephalons . . . with those of *O. gilberti* . . . shows some of the differences between the two species.

. . . .

"The species that is most nearly related appears to be *O. thompsoni,* but we find that the latter differs from *O. fremonti* in having: (a) a space between the glabella and the marginal rim; (b) a less expanded frontal glabellar lobe and longer palpebral lobes; (c) *O. fremonti* also has a peculiarly expanded pleural lobe of the third segment of the thorax.

"The same differences exist in relation to *O. lapworthi.* It differs from *O. logani* in details mentioned under that species.

. . . .

"The hypostoma is very rarely preserved. It is much like that of *O. gilberti* in having a denticulated posterior margin, and both are much like the hypostoma of *Paedeumias transitans.*

"The outer surface is similar to that of *O. gilberti* and other species of the genus."

Supplementary description.—Cephalon semicircular, moderately convex in profile; glabella slightly hourglass-shaped; anterior glabellar lobe rounding out slightly in front of eyes, extending to marginal furrow, front vertical in young, broader and lower with 45° slope in old adults; second glabellar furrow longest with lateral ends bent backward; third lobe chevron-shaped, shorter than second; fourth lobe chevron-shaped, wider, and slightly longer than third; occipital ring straight, same width as fourth glabellar furrow but a little longer, with a small posterior median node; dorsal furrow present along posterior glabellar sides, interrupted by palpebral lobes, then continuing around anterior lobe to coalesce with marginal furrow in front, very faint in larger cephala. First glabellar furrow deepest at sides, starting in a short distance, curving backward and becoming fainter across center; second glabellar furrow very faint at sides, curving up and in to be deep and diagonal, then faint across center; third glabellar furrow deep at sides, diagonal, absent through middle third; occipital furrow straight, diagonal, deep at sides, absent through center. Palpebral lobes strong, short, curving to opposite center of fourth glabellar lobe. Eye vertical, full length of lobe; palpebral furrow curved, well defined; fixed-cheek area lowest at anterior extremity opposite third glabellar lobe, widening and sloping upward posteriorly into a low knoll opposite end of eye, then sloping downward in all directions to posterior margin. Free-cheek areas of medium width, increasing posteriorly; marginal furrow well defined, continuous; border narrow, rimlike in young, flattening out a bit and widening posteriorly into base of long genal spines in larger cephala; a 45° angle in posterior margin approximately one-third distance in from the genal spine to dorsal furrow and at this angle in small cephala is a minute intergenal spine and from it a faint posterior facial suture ridge runs into base of eye.

Only known thorax (Walcott, 1910, pl. 37, fig. 7) shows 15 segments with a strong fifteenth axial spine, and a very extreme macropleural development of the third segment; first and second segments

have short falcate terminations but remainder are not well preserved; pygidium not known.

Outer surface of cephalon covered by low crowded imbricating ridges warped around and conforming to contours of cephalon; inner surface of free-cheek area covered with heavy anastomosing ridges radiating outward from eye.

Discussion.—Two cephala, one a large adult estimated as measuring 66 mm. in width by 32 mm. in length, and a smaller one, 23 by 13 mm., represent this species. Both are fragmentary, but supplement each other quite well. They are clearly conspecific with *O. fremonti* Walcott, and it is interesting to note that after observing such features as the low knoll on the fixed-cheek area and the minute intergenal spine on the limestone Mexican specimens, the author was surprised to find these same details on the flattened specimens of the type lot, though neither feature had been mentioned by Resser or Walcott. Following Resser's discussion of the species (1928, pp. 6-7), the author has considered as the cotypes the specimens figured by Walcott from loc. 52, with special emphasis on the adult cephalon, U.S.N.M. No. 56819a, which shows all the critical features including the fixed-cheek knoll which crushing has displaced slightly posteriorly. This feature is also shown on U.S.N.M. No. 56819i (Walcott, 1910, pl. 37, fig. 13), a small cephalon which was sketched by Walcott. Also on a small immature cephalon from locality 52, which is not figured, the author found minute intergenal spines in the same position as on the small Mexican cephalon. This feature appears to be characteristic only of the young.

The author has used basically the cephalon, U.S.N.M. No. 56819a, for the detailed description, supplementing the note on convexity from the Mexican limestone specimens. The specimen, U.S.N.M. No. 56822a, has been used for the description of the thorax, but the specimen is not well preserved and it will be noted that the anterior lobe of the glabella is much more expanded than in the main cotype, but how much is real and how much due to crushing cannot be determined; therefore, its position in the species should be considered doubtful. No thorax is associated with the cephala from locality 52.

It should be noted that the specimen, U.S.N.M. No. 56819a, represents actually a form of the species in which the base of the genal spines is in a somewhat forward position, lying opposite the posterior end of the eyes. The California specimens described by Resser represent this same variety. However, the Mexican specimens appear to have the genal spines directly at the posterolateral corners and in this respect are actually the normal form for the species. The specimens,

U.S.N.M. No. 15416, from locality 30, likewise show the genal spine in normal position, and are considered *Olenellus fremonti* Walcott by the author, although Resser (1928) would exclude them.

Hypotypes.—U.S.N.M. Nos. 115685, 115686.

Formation and locality.—Lower Cambrian, Buelna formation, 809a.

OLENELLUS, species undetermined

Two very fragmentary cephala of *Olenellus* which show a narrow brim similar to that of *Olenellus truemani* Walcott occur at the base of the *Obolella* beds, and thus represent the first appearance of *Olenellus* in the Mexican Lower Cambrian section. However, they are so fragmentary that many important details of the cephalon, including the length of the eyes, cannot be determined, and consequently it is impossible to identify the species.

Formation and locality.—Lower Cambrian, Puerto Blanco formation, 801b.

Genus PAEDEUMIAS WALCOTT, 1910

PAEDEUMIAS PUERTOBLANCOENSIS Lochman, new species

Plate 19, figures 9-16

Cephalon semicircular, with low convexity; holotype 10 mm. in width by 6 mm. in length; glabella low, slightly hourglass-shaped, tapering to a broad point anteriorly; anterior lobe of low convexity, narrow at base of palpebral lobes, widest just in front of lobes, then tapering forward to a broad, blunt point; second glabellar lobe short and flat in center, at sides curving forward, then bent backward; third glabellar lobe short, narrow, merging at sides with second lobe; fourth glabellar lobe apparently chevron-shaped, longer and wider than second. Occipital ring straight, as wide as and longer than fourth lobe; dorsal furrow narrow, faint but distinguishable along sides to first glabellar furrow. First glabellar furrow forming deep, arcuate slits at sides, absent across center; second glabellar furrow in form of deep, straight slits just below inner ends of first glabellar furrow, then becoming straight, broad, and very faint across the center; third glabellar furrow arcuate posteriorly, deep at sides, becoming progressively fainter at center; occipital furrow arcuate posteriorly, well defined at sides, faint across center. Palpebral lobes strong-based, wide, curving to opposite center of occipital ring; palpebral furrow arcuate, wide and clear along anterior half, then disappearing and reappearing again near end of eye lobe; eye vertical, extending full length of lobe. Fixed-cheek area small, sloping up from palpebral and

dorsal furrows into a low knoll opposite end of fourth glabellar lobe, sloping downward posteriorly to marginal furrow. Free-cheek area starting with a narrow brim in front of anterior lobe, increasing in width posteriorly; brim crossed on median line by a low narrow ridge extending from center of anterior lobe and interrupting marginal furrow; marginal furrow very narrow, distinct at front and sides, fainter posteriorly; border narrow, rimlike. Genal spine relatively short and intergenal spines very short in adult.

Thorax and pygidium not known.

Outer surface covered by fine wavy interrupted ridges, crossing test transversely and conforming somewhat to contour of cephalon.

Discussion.—This species is represented by protaspids and metaspids, and fragmentary cephala from six localities. The holotype is a young, nearly complete cephalon. A larger cephalon is fragmentary. An additional paratype is fairly well preserved but has had the front of the cephalon pushed back and up so that the brim is abnormally short and the anterior lobe of the glabella appears somewhat broader.

The species is very close to *P. transitans* Walcott. It appears to differ from that species only in the more rounded anterior lobe of the glabella and the straight posterior margin of the cephalon. As the type of *P. transitans* is a flattened, somewhat crushed shale specimen, the author is unable to determine how much the difference in matrix has affected these details of the cephalon. She considers it feasible for the present to describe the Mexican material as a new species but to call attention to its close relation to *P. transitans.*

In studying the species of *Paedeumias* the author concluded that nearly all the same features listed for *Olenellus* constitute features of specific value in *Paedeumias,* i.e. (1) length of eye, (2) shape of anterior glabellar lobe, (3) width of brim and structure of median anterior ridge. In *Paedeumias,* however, there appears to be no variation in the width of the border, the narrow, rimlike border being apparently a generic character.

Types.—Holotype, U.S.N.M. No. 115703; paratypes: cranidia, U.S.N.M. Nos. 115705a, 115706-115708; protaspids, U.S.N.M. No. 115708; fragments, U.S.N.M. Nos. 115709, 115710.

Formation and locality.—Lower Cambrian, Buelna formation, 801e, 801f, 807c, 809a, 807b, 807e.

Genus WANNERIA Walcott, 1910

WANNERIA MEXICANA, new species, and W. M. PRIMA Lochman, new variety

Plate 18, figures 1-3

Cephalon semicircular; small cephala with strong convexity, but larger cephala appearing to have only moderate convexity. Glabella parallel-sided posteriorly, expanding anteriorly; anterior lobe of low convexity, with vertical front, reaching to marginal furrow, its greatest width at a bulge just in front of bases of palpebral lobes; second glabellar lobe of medium length, arcuate; third glabellar lobe chevron-shaped, slightly longer, but narrower; fourth glabellar lobe chevron-shaped, a little shorter and narrower than fourth lobe; occipital ring straight across, same length and width as fourth lobe, with a short median posterior spine. Dorsal furrow faint, running forward and outward to second glabellar furrow, curving in and around second glabellar lobe, disappearing across palpebral lobes, then continuing faintly around anterior lobe and coalescing with marginal furrow. First glabellar furrow well defined, slightly arcuate, running from palpebral lobes; second glabellar furrow curving in and back from dorsal furrow, nearly obsolete in center; third glabellar furrow well-defined, curving in, back and across center. Occipital furrow nearly straight across, deep at sides, faint in center. Palpebral lobes thick with strong base at anterior glabellar lobe, extending in a low arc to opposite third glabellar furrow; palpebral furrow not seen. Eye vertical, extending full length of palpebral lobe; fixed-cheek area very small, starting opposite second glabellar furrow, the part opposite third glabellar furrow rising almost vertically to palpebral lobe, posteriorly only a gentle rise, then the surface slopes down to marginal furrow; free-cheek area of medium width, widening posteriorly to equal width of anterior lobe, strongly convex in small cephala; marginal furrow wide, well defined around cephalon; border of medium width, convex, widest at base of genal spines and narrower around front and also noticeably narrower along posterior margin. In this species it is presumed that the long, medium-sized genal spines would lie at the posterolateral angles, and the intergenal spines would be small and in a short distance on the posterior margin.

Fragmentary hypostoma shows a large circular, strongly convex anterior lobe with a large macula at each posterior corner; a narrow, flat, crescent-shaped posterior border with six small teeth on each side.

Thorax and pygidium not known. Surface of test not known.

Description of variety.—The cephalon of the variety is like that of the species in all proportions and details except for the position and

size of the genal and intergenal spines which are placed as follows: At the posterolateral angle at the end of the strong posterior facial suture ridge lie medium-sized intergenal spines, projecting somewhat laterally; the long, heavy genal spines lie on a line with the first glabellar furrow, and the spine projects nearly straight outward at the side of the cephalon, with a slight upward flexure at the base.

Discussion.—This striking form is represented by a number of cephala of various sizes, but all the material has weathered out on the surface of a dense limestone from which it is impossible to break out any specimens. Unfortunately all the cephala have been quite deeply weathered, so that not only is the surface gone or badly worn, but in most the weathering has reached down to the limestone underneath the specimen. As a result it is hard to judge many of the details and the original convexity.

The species is most closely related to the other two Cordilleran *Wanneria* species, *W. rowei* (Walcott) and *W. occidens* Walcott, but in so far as comparison can be made it differs from them in (1) the sudden bulge of the anterior lobe just in front of the palpebral lobes, (2) the very short occipital spine, and (3) the somewhat shorter eyes. The author recognizes this form as a species differing from described ones as noted above; and this particular form as a variety of that species in which the intergenal and genal spines are placed as noted.

In association with this variety from locality 801c on the same weathered slabs are a number of small cephala, ranging from 2 mm. to 9 mm. in length. All specimens are so deeply weathered that their positive identification is difficult, but it can be seen that on them the genal spines lie at the posterolateral angle of the cephalon. While the preservation of the glabella and eyes is so poor that they cannot positively be placed in *Wanneria,* the author believes it possible that they may represent the normal form of the species, *Wanneria mexicana.* It should also be mentioned that in the United States National Museum material from locality 61k, Hota shale, Mumm Peak, British Columbia, several cephala occur which have never been described, but which represent the same species and variety as *W. mexicana prima.* They are associated with specimens of *Wanneria occidens* Walcott, and an undescribed variety of that species which has the intergenal and genal spines in the same position as the Mexican species and variety.

The occurrence of both this species of *Wanneria* and *Olenellus truemani* Walcott together in the Hota shale and the Mexican section suggests a close relationship between the faunas.

Types.—Holotype, U.S.N.M. No. 115681; paratypes, U.S.N.M. Nos. 115682, 115683; unfigured paratypes, U.S.N.M. No. 115684.

Formation and locality.—Lower Cambrian, Puerto Blanco formation, 801c.

WANNERIA WALCOTTANA BUELNAENSIS Lochman, new variety

Plate 19, figures 1-6

Description of variety.—The cephalon of the variety is like that of the species in all proportions and details except for the position and size of the genal and intergenal spines; the intergenal spine is quite small on the two cephala where it is preserved and lies at the posterolateral corners of the cephalon. From it the border slopes forward and outward bringing the base of the medium-sized genal spine a short distance anterior to the posterior end of the eye. The straight genal spine projects backward and slightly outward. On the holotype, a low knoll occurs on the posterior limb back of the end of the eye. All other specimens are too poorly preserved to show this part of the carapace, therefore it is not certain whether this is a feature of preservation or of constant varietal importance.

Discussion.—The holotype of this variety is a cephalon 24 mm. in length, and though not complete, does permit specific determination. It is most interesting to find the occurrence of this variety of the common Appalachian species in the Cordilleran trough. It agrees with *Wanneria walcottana* (Wanner) and differs from all other described species in the following features: (1) A regular and smooth expansion of the anterior lobe of the glabella; (2) the presence of a row of pits along the inner edge of the border; (3) the eyes and palpebral lobes reaching just to the center of the fourth glabellar lobe; (4) an occipital node rather than spine; (5) a very small intergenal spine, apparently aborted in large adults; (6) a medium-sized genal spine.

The material contains a number of large fragments consisting of broken glabellae and free-cheek areas. These are believed to represent the same species and variety, though they are specifically undeterminable. These fragments have the network ornamentation of the surface beautifully preserved, and indicate that the individual adults of this variety reached as large a size as the Appalachian specimens. Several associated hypostoma show the same network ornamentation on their ventral surface.

A number of associated metaspids are well preserved and show that the genal spine is in advanced position even at this stage.

Types.—Holotype, U.S.N.M. No. 115695; paratypes: fragmentary glabellas and free cheeks, U.S.N.M. Nos. 115696, 115697; protaspids,

U.S.N.M. No. 115700; small cephala, U.S.N.M. No. 115699; hypostoma, U.S.N.M. No. 115698.

Formation and locality.—Lower Cambrian, Buelna formation, 807b.

WANNERIA? species undetermined

Plate 19, figures 7, 8

A small collection from quartzite beds at an isolated locality consists of five fragmentary cephala, a large broken hypostoma, and a protaspid, all belonging to an olenellid genus. However, the specimens are only broken internal molds of quartzite and the preservation is so poor as to make identification uncertain. Generic reference to *Wanneria* is made because the specimens show short eyes, the ends of the palpebral lobes reaching not quite to the center of the fourth glabellar lobe. In this respect they are comparable to those of *Wanneria mexicana prima.* However, on the posterior margin two-thirds the distance out from the dorsal furrow there is a noticable bend, but no intergenal spine can be seen. The genal spine is at the posterolateral corner of the cephalon. They may represent the normal form of the species, *Wanneria mexicana,* but until more complete material is obtained, nothing definite can be determined.

Figured specimens.—U.S.N.M. Nos. 115701, 115702.

Formation and locality.—Lower Cambrian quartzite, Proveedora formation, 807j.

Family CORYNEXOCHIDAE Angelin, 1854

Genus BONNIA Walcott, 1916

BONNIA SONORA Lochman, new species

Plate 21, figures 1-7

Single known cranidium small, 1.8 mm. in length by 2 mm. across the eyes; glabella occupying central half of cranidium, convex, becoming steep and vertical anterior to palpebral lobes, expanding somewhat forward to a nearly flat, broad front (some distortion to left in cranidium may cause a greater than true expansion); faint coloration indicates a posterior, slightly curved glabellar furrow extending practically across, and another glabellar furrow in front of it, very short and at sides only. Dorsal furrow well defined at sides forward to a clear rounded pit on each side of glabella opposite anterior end of palpebral lobe, then much narrower and shallower around front of glabella. Occipital furrow wide and deep. Occipital ring narrow, nearly flat, possibly with a low median node; no brim; fixed cheeks slope regularly to broad, very shallow marginal furrow which merges

into dorsal furrow. Border a narrow, convex, vertical rim; anterior margin rounded. Fixed cheeks approximately one-half width of glabella, very slightly convex, downsloping; palpebral lobes medium size, just back of midline of glabella; palpebral furrow narrow, well defined; ocular ridge obsolete; posterior limbs of medium width, starting opposite third glabellar furrow, same length as occipital ring, crossed by a narrow, shallow marginal furrow. Free cheek not known. Facial suture cutting anterior margin just within genal angle. Outer surface apparently smooth, but definitely worn; a few minute transverse ridges distinguishable on border.

Thorax not known.

Pygidium semicircular, convex; axis of medium width, convex, sides subparallel to a broadly rounded end which does not quite reach border, divided into three segments and a long terminal portion by three broad shallow furrows; dorsal furrow broad, well defined at sides only; pleural platforms slightly wider than axis, flat near dorsal furrow, then curving down steeply to narrow, well-defined marginal furrow; border of medium width, slightly convex, continuing slope of pleural platforms; a very small anterior marginal spine at each side; posterior margin smoothly rounded; surfaces poorly preserved.

Discussion.—This species is described from a single small cranidium and seven pygidia ranging from 4 mm. by $2\frac{1}{2}$ mm. to 8 mm. by $4\frac{3}{4}$ mm. All the pygidia are poorly preserved; only one specimen shows the very small marginal spine. The species is close to three described species but differs from them as indicated. *Bonnia tensa* Resser and *Bonnia fieldensis* (Walcott) have all proportions and convexity practically the same, but both differ in that the glabella merges into the border as the marginal furrow is almost obsolete; and *B. tensa* Resser also has a steeper frontal slope of the glabella. A small cranidium in the *B. fieldensis* lot, which is the same size as the Mexican specimen, differs from it in exactly the same features as the larger *B. fieldensis* cranidia. This indicates that the specific features are already established in cranidia of this small size. Pygidia of the same size as *B. fieldensis* and *B. sonora* do not show any differences. The Mexican species is closest of all to *B. columbensis* Resser from the Mount Whyte formation. The cranidium differs in (1) the steep slope of the front part of the fixed cheeks, and (2) the nearly flat profile of the glabella. In the pygidium of *B. columbensis* the marginal furrow is more distinct, especially around the back, and the posterior border tends to flatten out. With the present limited material representing both species, it is possible that, when more material is obtained, the Mexican species can be shown to be the same as *B. columbensis* Resser.

Types.—Holotype, U.S.N.M. No. 115736; paratypes, pygidia, U.S.N.M. Nos. 115737, 115738, 115739.

Formation and locality.—Lower Cambrian, Buelna formation, 809a.

Family INCERTAE SEDIS

Genus ANTAGMUS Resser, 1936

ANTAGMUS BUTTSI (Resser)

Plate 21, figures 15-21

Ptychoparella buttsi RESSER, Geol. Soc. Amer. Spec. Pap. 15, p. 97, 1939.
Antagmus buttsi (Resser) LOCHMAN, Journ. Paleontol., vol. 21, p. 63, 1947.

Original description.—"This species is characterized by the width of the cranidium at the anterior end of the eyes. The thorax has 15 segments, and this is one of the few specimens of the genus which preserves the pygidium. It is small, well fused, and the rear portion is turned down so that it stands vertically."

Supplementary description.—Cranidium nearly square, slightly wider than long; glabella broadly conical, with nearly straight front, moderately convex; profile highest posteriorly, sloping anteriorly; three pairs of short faint glabellar furrows at sides only; first and second glabellar furrows apparently straight, third slightly arcuate. Occipital furrow broad, well defined, slightly deeper at sides. Occipital ring narrow at sides, expanding to medium in center, slightly convex; dorsal furrow broad, well defined at sides, shallow across front. Brim of medium width, gently convex, sloping steeply at sides but nearly flat at center; marginal furrow broad, shallow at sides, apparently fading at center to form a broad, but slight, indentation. Border of medium width, very slightly convex, horizontal; anterior margin rounded. Fixed cheeks two-thirds width of glabella, slightly convex, horizontal. Palpebral lobes small, prominent, on midline of glabella; palpebral furrow narrow, faint. Ocular ridge narrow, well defined, curving to just behind front of glabella; posterior limbs same width as occipital ring, crossed by a broad, well-defined marginal furrow. Free cheek triangular with small eye at inner angle; ocular platform of medium width, with moderate slope; border somewhat narrower, slightly convex, horizontal, with short anterior projection and short slender genal spine; marginal furrow narrow, shallow. Facial suture cutting anterior margin well out at sides, curving back to marginal furrow, then straight back, into, and around palpebral lobes, thence curving out and back to cut posterior margin within genal angle.

Thorax of 15 narrow segments; axis and pleural lobes of same width; pleural segments with short pointed falcate ends and crossed by shallow, medium-wide pleural furrows.

Pygidium small, narrow, transverse in outline; axis broad, slightly convex, sides tapered very slightly to broadly rounded end, not quite reaching margin; segments not distinguishable; dorsal furrow narrow, apparently at sides only; pleural platforms somewhat narrower than axis, gently sloping; two or three segments may be present; marginal furrow not preserved; border narrow, gently sloping at sides, vertical in position posteriorly.

Outer and inner surfaces of test not known.

Discussion.—This species is represented in the Mexican material by 10 cranidia ranging in length from 3 mm. to 6.5 mm.

The holotype of *Antagmus buttsi* (Resser), U.S.N.M. No. 94771, though a complete carapace, is only a mold in fine yellow sandy shale, and the cephalon as a whole is distorted and poorly preserved. The glabella is flattened and worn off on top and the entire border is broken off, but the approximate width can be estimated from a trace of the anterior margin running along the right side. Likewise, the preservation has rendered a complete description of the pygidium impossible. In trying to compare the Mexican specimens with this material, all the cranidia in the type lot were examined, and while they showed all sorts of distortion, several are better preserved than the holotype. The cranidia which had received only slanting lateral pressure were best preserved, and showed a brim and border of the same width, convexity, and slope as the Mexican specimens.

The species differs from *A. solitarius* Lochman in its much wider brim, somewhat more convex fixed cheeks, and the slight divergence of the anterior facial suture. It differs from all other described species of *Antagmus* except *A. perola* (Walcott) in the much greater width of the brim. The proportions and width of the brim and border are the same in the two species, and the only difference noted is the convex and sloping condition of the brim, and (in some specimens) of the border in *A. perola* (Walcott). As this species is preserved in shale, it is impossible to be sure which feature is the true one, but it seems as if the brim, at least, were moderately convex and regularly sloping in the normal condition. *A. perola* (Walcott) is the only other species of *Antagmus* in which the thorax of 15 segments is known, but only two of the specimens in the type lot have the pygidium, which is not well preserved. What can be determined of it would certainly indicate a congeneric relation, but more detailed analysis cannot be made.

Hypotypes.—U.S.N.M. Nos. 115743a, b, 115744, 115745; unfigured hypotypes, U.S.N.M. No. 115746.

Formation and locality.—Lower Cambrian, Buelna formation, 809a.

ANTAGMUS SOLITARIUS Lochman, new species

Plate 21, figures 8-11

Cranidium square, largest specimen 5 mm. by 5 mm.; glabella conical with straight front, moderately convex, with posterior highest, sloping anteriorly; three pairs of short, faint glabellar furrows at sides only; first pair straight, second and third pairs slightly arcuate. Occipital furrow of medium width, deep at sides, shallow through center. Occipital ring slightly convex, narrow at sides, expanding to center, with a small median node. Dorsal furrow broad, well defined at sides, shallow across front of glabella. Brim narrow, flat, sloping gently at center, steeper at sides; marginal furrow broad, well defined for nearly entire length, fading at center with a very slight V-shaped indentation, border medium wide, strongly convex, horizontal; anterior margin rounded. Fixed cheeks two-thirds width of glabella, slightly convex, horizontal. Palpebral lobes small, on midline of glabella; palpebral furrow narrow, shallow; ocular ridge low, narrow, curving slightly to just behind the front of the glabella; posterior limbs narrow, approximately same length as occipital ring, crossed by a broad shallow marginal furrow. Free cheek not known. Facial suture cutting anterior margin well out at sides, curving out to furrow, then running straight back to and curving around palpebral lobes, thence curving out and back to cut posterior margin within genal angle. Outer surface of test finely granulated.

Thorax and pygidium not known.

Discussion.—This species is known from one small adult cranidium of which the brim is somewhat crushed, and a smaller cranidium, under 3 mm. in length, which is broken at the edges of the cheeks, palpebral lobes, and posterior limbs. It corresponds closely in all preserved parts to the larger cranidium, and has an undamaged brim.

The species is very close to *A. typicalis* Resser in the very narrow brim but differs in the convex border and the straight anterior facial suture. From *A. tennesseensis* it differs in the wider brim and the diverging facial suture of the latter species, although the preservation of both species makes it difficult to determine the true course of this suture. In the type lot of *A. tennesseensis* several cranidia show a straight suture while others have a slight divergence. In the cranidia of *A. solitarius* it appears to go straight forward, but this portion of the specimens is not well preserved.

Types.—Holotype, U.S.N.M. No. 115740; paratype, U.S.N.M. No. 115741.

Formation and locality.—Lower Cambrian, Buelna formation, 809a.

Genus **ONCHOCEPHALUS** Resser, 1937

ONCHOCEPHALUS BUELNAENSIS Lochman, new species

Plate 20, figures 5, 18-29

Cranidium subquadrate, average dimensions $5\frac{1}{2}$ mm. across the eyes by $4\frac{3}{4}$ mm. in length; glabella conical with a nearly straight front, moderately convex, with greatest elevation in posterior and sloping regularly to quite low anteriorly. Three pairs of glabellar furrows at sides only, first pair straight, very faint; second pair well defined, slightly arcuate; third pair well defined, arcuate. Occipital furrow distinct, broad, deep at sides, shallower through middle. Occipital ring narrow at sides, expanding at center with a minute median node; dorsal furrow broad, deep at sides, shallow around front; brim nearly flat, slightly sloping, of medium width at sides, narrowing in front of glabella. Marginal furrow broad, shallow at sides, becoming very shallow on median line and bending into a broad V. Border narrow, with median expansion, horizontal posteriorly, then curving downward anteriorly; anterior margin rounded. Fixed cheeks three-fourths width of glabella, slightly convex, slightly downsloping. Palpebral lobes small, on midline through glabella; palpebral furrow narrow, shallow; ocular ridges narrow, curving slightly into dorsal furrow behind front of glabella. Posterior limbs short, same width as occipital ring, crossed by a broad, shallow marginal furrow. Free cheek narrow, elongate with small eye at inner angle; ocular platform of medium width, flat and sloping slightly. Marginal furrow narrow, very faint; border narrow, horizontal on inside, curving down on outside, with a short-pointed anterior projection and a short slender genal spine. Facial suture cutting anterior margin about halfway from center, curving out to marginal furrow, then back, into and around the palpebral lobes, thence out and back to cut posterior margin within genal angle. Outer surface of test finely granulated; inner surface showing coarse venation on brim, and scattered fine punctations.

Thorax not known.

Pygidium small, transverse, only moderately convex, $3\frac{1}{2}$ mm. wide by $1\frac{1}{2}$ mm. in length; axis broad, slightly convex, sides subparallel to broadly rounded end, not quite reaching marginal furrow. Anterior half segment well defined by furrow; second segment set off by a very faint broad furrow with a low oval bulge on each side of

center; third segment broad, set off by a broad faint arcuate furrow with two low oval bulges halfway in on each side; terminal portion narrow. Dorsal furrow narrow, faint. Pleural platforms three-fourths width of axis, sloping gently with two anterior segments and a terminal portion divided by narrow interpleural grooves running clear to margin, well-defined pleural furrows. Marginal furrow faint. Border narrow, flat, horizontal at sides, steeply sloping at back; posterior margin with a distinct indentation at median line; outer surface finely granulated; inner surface not known.

Remarks.—This species is known from a number of cranidia and some free cheeks and pygidia. The holotype cranidium and some of the paratypes are from locality 807c, and while they have a clear outline and are fresh, the outer surface has invariably been torn in breaking them out. Therefore, all the furrows are slightly deeper and the ocular ridges stronger than in specimens preserving the outer surface. This feature can be readily demonstrated by partially peeled cranidia in collection from locality 809a.

In so far as the type, *Onchocephalus thia* (Walcott), can be compared accurately, because of its poor preservation, it appears to be very similar to *O. buelnaensis,* but differs from it in having the brim narrower, flat, and definitely horizontal in position. In *O. leuka* (Walcott) the wider, flat, slightly ascending border is quite different. *O. buelnaensis* seems quite close to *O. virginicus* (Resser), but the preservation of the single holotype cranidium of that species is so poor that specific characters are not really distinguishable.

Types.—Holotype, U.S.N.M. No. 115724; paratypes: cranidia, U.S.N.M. Nos. 115725, 115727, 115733; free cheeks, U.S.N.M. No. 115726; pygidia, U.S.N.M. Nos. 115729, 115731, 115732; unfigured paratypes, U.S.N.M. Nos. 115728, 115730, 115734-115735.

Formation and locality.—Lower Cambrian, Buelna formation, 809a, 807c, 801f.

ONCHOCEPHALUS MEXICANUS Lochman, new species

Plate 20, figures 6-17

Cranidium rectangular, average dimensions 6 mm. across the eyes by 5 mm. in length; glabella moderately convex, highest posteriorly, sloping to low anteriorly; conical with a nearly straight front. Three pairs of faint short glabellar furrows, first and second pairs straight, third pair arcuate; dorsal furrow broad, distinct at sides, shallow across front of glabella. Occipital furrow of medium width, deep at sides, very shallow across center. Occipital ring narrow at sides, expanding in center with probably a small median node. Brim of medium

width, moderately convex at sides, only slightly convex in front of glabella, continuing downslope of glabella. Marginal furrow broad, distinct at sides, faint in center where it appears to bend slightly back to form V. Border narrow, expanding backward on midline, slightly convex, descending; anterior margin rounded. Fixed cheeks three-fourths width of glabella, slightly convex, downsloping; palpebral lobes small, on midline through glabella; palpebral furrow narrow, shallow; ocular ridges practically obsolete, slightly curved to just back of front of glabella; posterior limbs short, only slightly wider than occipital ring, crossed by a broad, shallow marginal furrow. Free cheek narrow, elongate, with small eye at inner angle. Ocular platform of medium width, flat, gently sloping; marginal furrow very faint; border narrow, slightly convex, descending regularly, with a short anterior projection and a short slender genal spine. Facial suture cutting anterior margin on line with dorsal furrow, curving out to marginal furrow, then straight back and around palpebral lobes; then curving out and back to cut posterior margin within genal angle. Outer surface of test finely granulated; inner surface appears smooth.

Pygidium small, transverse, $2\frac{1}{2}$ mm. wide by 1 mm. long, convex, axis broad, moderately convex, sides subparallel to broadly rounded end, not quite reaching marginal furrow. Three faint axial furrows, anterior one nearly across, others only at sides, marking off three segments and a terminal portion; dorsal furrow narrow, faint; pleural platforms one-half width of axis, flat near dorsal furrow, then dropping down very steeply to a very faint marginal furrow. Interpleural grooves narrow, running out across the border, dividing two anterior segments, crossed by pleural furrows, and a terminal portion; border narrow, flat, sloping down slightly at sides but becoming vertical at posterior median line. Outer surface finely granulated; inner surface not known.

Remarks.—This species is extremely abundant in locality 809a, but is only sparsely represented at the other localities. The cranidia are numbered in the hundreds, but only 12 pygidia were obtained, a fact probably due to their small size. In trying to determine which pygidium to associate with which cranidium in these two species of *Onchocephalus,* the author decided to assign the more convex type of pygidium to the more convex cranidium. Likewise, the free cheek with the more convex ocular platform was associated with the more convex cranidium.

Onchocephalus mexicanus Lochman as here recognized differs from *O. buelnaensis* in the steeper descent of the brim and continued downslope of the border of the cranidium, and the steep slope of the pleural

platforms of the pygidium. The species are definitely close, but the cranidia from each locality can be separated into the two types. The author was not able to demonstrate a gradational series between the two types, but if a hundred or more specimens are cleaned, it may be possible to show such a feature. This would afford a very interesting problem as plenty of material is available.

Types.—Holotype, U.S.N.M. No. 115713; paratypes: cranidia, U.S.N.M. Nos. 115714, 115717, 115719; free cheeks, U.S.N.M. No. 115718; pygidia, U.S.N.M. Nos. 115715, 115716; unfigured paratypes, U.S.N.M. Nos. 115720-115723.

Formation and locality.—Lower Cambrian, Buelna limestone, 809a, 809b, 807c, 801f.

Genus SOMBRERELLA Lochman, 1948

SOMBRERELLA MEXICANA Lochman

Plate 20, figures 1-4

Sombrerella mexicana LOCHMAN, Journ. Paleontol., vol. 22, p. 454, pl. 70, figs. 15-18, 1948.

Original description.—Cranidium subquadrate, 4 mm. across eyes by $4\frac{1}{2}$ mm. in length; glabella narrowly conical with straight front, strongly convex with appearance of a median ridge, profile highest posteriorly, sloping steeply down to a very low anterior; three short, extremely faint glabellar furrows; occipital furrow narrow, present at sides but nearly obsolete across center; occipital ring flat, narrow at sides, expanding rapidly to center with a node on posterior margin, in profile continuing upward slope of back of glabella; brim narrow, flat, sloping at sides, horizontal at center; marginal furrow broad, shallow, narrower toward center with a suggestion of a medium indentation; border of medium width, moderately convex, horizontal; anterior margin rounded. Fixed cheeks approximately one-half width of glabella, horizontal; palpebral lobes small, slightly forward of center but not on anterior one-third of glabella; palpebral furrow shallow, faint; ocular ridge narrow, well defined, slightly curved to just behind front of glabella; posterior limbs same width as occipital ring. Free cheek not known. Facial suture cutting anterior margin well out at sides, running out and back to marginal furrow, then back and in to and around palpebral lobes; thence curving out and back to cut posterior margin well within genal angle. Outer surface not known; inner surface with coarse punctations on brim and medium-sized punctations on fixed cheeks and posterior limbs.

Thorax and pygidium not known.

Discussion.—Only two small cranidia represent this genus and

species. The broken glabella on the paratype suggests that this exposed portion of the cranidium was especially subject to damage. Although the top is broken, the glabella in the paratype does not seem quite so narrow and steep as in the holotype, so that some question still remains as to whether the extreme appearance of the holotype may not be due to some slight distortion of the specimen which cannot now be detected.

Types.—Holotype: cranidium, U.S.N.M. No. 115712; paratype: broken cranidium, U.S.N.M. No. 115711.

Formation and locality.—Lower Cambrian, Buelna formation, 809a.

GENUS AND SPECIES UNDETERMINED 1

Plate 21, figures 13, 14

Cranidium wide, subquadrate, $7\frac{1}{2}$ mm. across eyes by 6 mm. in length; glabella narrow, conical with nearly straight front, moderately convex, high posteriorly with steep slope anteriorly; three pairs of short straight glabellar furrows at sides only, becoming slightly longer posteriorly; occipital furrow broad, deep; occipital ring narrow, expanding to medium at center, slightly convex; dorsal furrow broad, well defined all around glabella; brim of medium width, flat, sloping moderately at sides, very slightly in center; marginal furrow narrow, very shallow at sides, apparently obsolete in center; border damaged but appearing at least medium in width. Fixed cheeks wider than glabella by one-fourth more than the width of glabella, very gently convex, horizontal; palpebral lobes small, prominent, on midline through glabella; palpebral furrow shallow, very faint; ocular ridge narrow, well defined, curving to near front of glabella; posterior limbs $1\frac{3}{4}$ times the width of occipital ring, crossed by a broad, well-defined marginal furrow. Free cheek not known. Facial suture at anterior margin not known from marginal furrow running straight back and slightly in to and around palpebral lobes, then curving out and abruptly back to cut posterior margin within genal angle (most of width of limb is caused by the wide fixed cheeks, and the limb itself actually extends only a short distance beyond the palpebral lobe). Outer surface finely granulated; inner surface not known.

Thorax and pygidium not known.

Discussion.—Only a single cranidium, which appears fairly well preserved except for the loss of the border and slight damage to the brim and right fixed cheek, is known. The author can detect no evidence of distortion, yet the cranidium presents a combination of generic characters which is not known in any described Lower Cambrian genus. However, the one cranidium is not specifically determinable

because of the damage, and the author will not erect a new genus on such a specimen.

The combination of generic characters which makes the cranidium unique is:

1. The palpebral lobes small, on midline of glabella.
2. Glabella narrow, conical with straight front, regularly convex; with three pairs of short glabellar furrows.
3. Fixed cheeks $1\frac{1}{4}$ the width of the glabella.
4. Fixed cheeks horizontal.
5. Posterior limbs $1\frac{3}{4}$ width of the occipital ring.

The generic characters are listed and the specimen described and figured so that its affinities may be recognized when other cranidia like it are found.

Figured cranidium.—U.S.N.M. No. 115742.

Formation and locality.—Lower Cambrian, Buelna formation, 809a.

MIDDLE CAMBRIAN FAUNAS

PROBLEMATICUM III

Plate 28, figures 8-11

A collection from the Arrojos formation contains four small cone-shaped, apparently broken shells. They are composed of a thin black phosphatic material. Not enough can be determined from the specimens to make any accurate determination even of their phylum. The surface ornamentation at first glance suggests the Archaeostracan genus *Bradoria* of which one species, *B. rugulosa* Matthew, has similar concentric ridges on the surface. *Bradoria* is described from the Lower Cambrian of Nova Scotia and the test is also of dark phosphatic material. However, *Bradoria* has no central apex to the carapace. None of the Mexican specimens, even though broken, give any suggestion of an ocular tubercle, a straight hinge line, or even the general shape of the *Bradoria* carapace.

The author believes that the specimens show some resemblance to the type of small cone-shaped shells described as *Kinsabia varigata* Lochman from the early Upper Cambrian. However, the shells of *Kinsabia* have a very distinct calcareous composition quite unlike the phosphatic material of these Mexican specimens. Therefore, it seems unwise to assign them to any named Cambrian genus at present because their affinities are clearly not determinable. A brief description covering the salient characters of the shells is given below and they are figured for future reference.

Shell a low, elongate cone composed of a thin layer of calcareo-

phosphatic material, none of the specimens showing a complete outline, as all have ragged outer edges; center of cone nearly central or slightly excentric in position; surface ornamentation quite distinctive consisting of (1) a nearly smooth apical area marked by only a few puncta, (2) surrounded by a long series of concentrically arranged ridges which make about a half turn and then bifurcate, (3) toward the outer half of the cone the ridges anastomose so closely as to produce a coarse reticulate pattern.

The largest specimen measures 3 by 2 mm.

Figured specimens.—U.S.N.M. Nos. 115920, 115921.

Formation and locality.—Middle Cambrian, Arrojos formation, 800d.

Phylum PORIFERA

Order Hexactinellida

Family CHANCELLORIDAE Walcott, 1920

Genus CHANCELLORIA Walcott, 1920

CHANCELLORIA EROS Walcott

Plate 28, figures 1-7

Chancelloria eros Walcott, Smithsonian Misc. Coll., vol. 67, No. 6, p. 329, pl. 86, figs. 2, 2a-c; pl. 88, figs. 1, 1a-f, 1920.

Original description.—"General form tubular, finger-shaped or in fronds of varying outline; there are twelve of the elongate and four frond-like specimens in the collection, all of which are flattened in the shale; that they were hollow or filled with very soft tissue is indicated by a specimen in which the greatly reduced space between the walls is filled with a thin layer of shale between the dermal spicular layers of the former opposite walls.

"*Reticulum.*—The skeletal spicules are not united to form a connected framework but occur more or less irregularly in the walls of the sponge. In specimens preserving the dermal layer intact only the outlines of the spicular rays are to be seen, the spicules being embedded in the compact skin-like layer; when the dermal layer has been partially removed, either before or after being embedded in the sediment, two of the rays of each spicule are exposed with their points extending upward, and it is only when the spicules have been displaced in relation to the dermal layer that their structure is revealed; the two exposed rays diverge at an angle of from 80 to 90 degrees, and the first impression is that they represent two actines of a triaene spicule, but displaced spicules in the outer layer (extosome) and flat-lying

spicules in the inner layer (endosome) prove that the spicules have a definite body formed of a small disk hollowed out on one side and slightly convex on the other side; some show a tubercle that in one spicule appears as though it might have been the base of a vertical ray with a central canal; there are from 4 to 9 rays, each of which is truncated at its inner end where it joins the central disk, it is then expanded and fitted closely to the adjacent rays for a short distance; a clearly defined line delimits the inner end and sides of each ray within the disk; the base of each ray is swollen and has a shallow round pit on the upper side corresponding in appearance to the hollow on the central disk; the rays taper rapidly from where they join the body of the spicule and each one forms a slender, straight or curved acicular ray; the rays may be nearly on a plane or may curve downward into an umbrella-like form; apparently there are some two or three rayed spicules with a swollen central body, but these may be portions broken off from many-rayed spicules. The presence of a vertical or axial ray on the larger stellate spicules is not readily proven for, if present, they have been crushed down into the mud and concealed or broken off; it is the presence of an apparently broken-off base in the center of the body that leads to the conclusion that a vertical ray existed; there is also a strong probability of its presence as it occurs on similar spicules in *Chancelloria drusilla.*

"The central body of the spicules appears to have been embedded in the outer wall (ectosome) with its convex side towards the base and the transverse axis horizontal or nearly at right angles to the vertical axis of the sponge, two of its rays turned upward just beneath this dermal outer covering and the others were embedded in the cortex within; an inner wall of flat-lying spicules is indicated by one specimen. Tufts of fine slender spicules occur along the upper margin that appear to be pressed down with the rays of the longer spicules.

"*Dimensions.*—The largest specimen has a length of 95 mm., with a width as flattened on the shale of 20 mm. at its upper end and 5 mm. where broken off at the basal end. A frondlike specimen is 38 by 41 mm., and is broadly rounded at the top and almost transverse at the base. The two exposed rays of the spicules in the elongate specimen average from 2.5 to 3 mm. in length in the upper half and from 1.5 to 2 mm. in the lower part; a small-sized, six-rayed spicule, 3 mm. in diameter from the tips of the rays, has the following proportions; body of spicule 0.5 mm., central disk or node 0.25 mm., length of ray from where it joins the body to its tip 1.25 mm.; some large detached spicules have rays 10 mm. in length but these may belong to a separate and as yet unrecognized species."

Discussion.—Hundreds of detached sponge spicules occur in locality 800c and a few have been obtained from localities 801n and 800a. All are readily referrable to the genus *Chancelloria,* and are for the present identified as *C. eros* Walcott from the Burgess shale. All details of spicular structure mentioned by Walcott under that species can be matched by specimens in the Mexican material, but the shape or dimensions of the body of the sponge are not known from these specimens. Since the individual spicules are so similar to those of *C. eros* Walcott, the author has preferred to assign them thus rather than describe a new species which could not, on the basis of the spicules, be differentiated from *C. eros.*

The best-preserved spicules show the individual rays with the inner end truncated where they fit against the central vertical ray and the flat edges where they fit against each other. The rays frequently separate along these sutures. Several spicules are illustrated in which the rays reach a length of 3 to 4 mm. but in all the blunt ends suggest that the ray is not now its full length. In a few spicules from locality 800c the vertical ray is still present or a clean break demonstrates its position, but in many the vertical ray appears to have been worn off. However, all four silicified spicules from locality 800a have it in place. Several broken spicules from locality 800c show a low knob with a central pit at the base of each ray.

The majority of the spicules in the collection from locality 800c show considerable wear and appear simply as six- or seven-rayed stars in which the central ray or disk is not separable from the side rays. The author believes that secondary deposition of calcite has taken place along the sutures and this has held the rays together. Many of these badly worn specimens show a pit in the central disk. Comparison with the silicified specimens in the collection from locality 800a, in which such a pit is indicated on the base of the vertical ray, suggests that such specimens are being viewed from the lower surface.

The side rays of the Mexican spicules number 4 to 7, with spicules of 6 or 7 side rays being commonest. The most complete side rays are slightly curved (pl. 28, fig. 4). In all the Mexican spicules in which the feature can be accurately observed, the side rays appear to slant or curve upward from the base of the vertical ray at approximately a 30° angle.

Hypotypes.—U.S.N.M. Nos. 115912-115916, 115918, 115919a.

Formation and locality.—Middle Cambrian, Arrojos formation, 800a, 800c, 801n.

INCERTAE SEDIS

HYOLITHES SONORA Lochman, new species

Plate 27, figures 17-25

Shell conical, straight, with a nearly flat (very slightly convex) dorsal surface and a strongly convex ventral surface; transverse section with sharp lateral angles, the dorsoventral diameter on the midline measuring two-thirds the length of the dorsal side so that lateral angles are approximately 50°-52°. Estimated length of average shell between 25 and 30 mm., with 11-12 mm. the width at the aperture. Large fragments suggesting a length of 50 mm., with a width at aperture of 15 mm.

Outer surface of dorsal side crossed by regular, closely spaced, arcuate growth lines which indicate an upcurved lip at the dorsal aperture; outer surface of ventral side not known.

Surface of the internal mold crossed by innumerable very fine, concentric striations (approximately 20 in a millimeter); several narrow longitudinal ridges appearing along the outer edges in smaller shells; in the large fragment five narrow, well-defined, regularly spaced longitudinal ridges cross the dorsal surface, and 12 mm. from the aperture one additional narrow longitudinal ridge appears by implantation on each side of the median ridge; the appearance on the specimens suggests that these longitudinal ridges are caused by longitudinal grooves on the interior of the shell; the arcuate growth lines of the exterior cross the ridges without interruption.

A fragmentary operculum has a triangular shape with semicircular base; the surface is crossed by three or four semicircular grooves paralleling the base.

Discussion.—This species is represented by 10 or more specimens from the *Kootenia-Glossopleura* zone. The holotype is a small, broken internal mold which is free from the matrix and shows the very characteristic transverse section. The paratypes consist both of other well-preserved internal molds and three specimens showing the external surface. All are more or less still in the matrix. Several other badly weathered internal molds are also referred to this species, although their preservation is so poor that only the characteristic transverse section can be made out. Two opercula are known, but both are very fragmentary.

It is hard to compare *H. sonora* Lochman, new species, with the other described Middle Cambrian species of *Hyolithes* because of the usual poor preservation. *H. prolixus* Resser is represented by free specimens which have a different transverse section. *H. comptus*

Howell and *H. cercops* Walcott from the Spence shale are both flattened in shale, so that nothing can be told of the transverse section. The same condition plus quite poor preservation holds for *H. idahoensis* Resser from the Rennie shale. Consequently it is impossible to compare the various specimens accurately, though none of them shows the longitudinal ridges which can be seen on some of the specimens of *H. sonora* Lochman.

Types.—Holotype, U.S.N.M. No. 115902; paratypes, U.S.N.M. Nos. 115903-115910.

Formation and locality.—Middle Cambrian, Arrojos formation, 800a, 800c, 801L, 801n, 801-O.

Plylum MOLLUSCA

Class GASTROPODA

HELCIONELLA, species undetermined

Plate 28, figures 23-25

One small (2 mm.) specimen of *Helcionella* was obtained from 800c. It is an internal limestone mold, much worn and showing the many cracks which appear to characterize the worn organic pellets so common in this collection. The preservation is really too poor to warrant an exact specific identification, but it seems most closely to resemble *H. burlingi* Resser from the Langston formation, Bear River Range, Idaho. The apex curves forward but probably not far downward and five well-defined concentric ribs cross the anterior profile and die out on the lateral surfaces.

Figured specimen.—U.S.N.M. No. 115936.

Formation and locality.—Middle Cambrian, Arrojos formation, 800c.

Phylum ARTHROPODA

Class TRILOBITA

Family ALOKISTOCARIDAE Resser, 1939

ALOKISTOCARE ALTHEA Walcott

Plate 27, figures 3-8

Alokistocare althea WALCOTT, Smithsonian Misc. Coll., vol. 64, No. 3, p. 184, pl. 25, figs. 3, 3a, 4, 4a, 1916.—RESSER, Smithsonian Misc. Coll., vol. 93, No. 5, p. 6, 1935; Carnegie Inst. Washington Publ. 563, p. 203, pl. 22, figs. 6-11.

Original description.—"This species is represented by casts of several specimens of the cranidium that are preserved in a fine sandstone

matrix. Nothing is known of the surface of the test, and only indistinct traces of the glabellar furrows are to be seen. The most nearly related cranidium is that represented by figures 4, 4*a*, plate 25, which differs in details of frontal rim and boss. The two forms are, however, closely related and may belong to the same species, the apparent differences being caused by the condition of preservation of the specimens. *Alokistocare althea* occurs in a fine sandstone matrix and the variety in a sandy shale; the two beds are separated stratigraphically by 200 to 300 feet in thickness of sandy shale."

Supplementary description.—Cranidium slightly elongate; glabella conical, with broadly rounded front, only slightly convex, highest posterior to low anteriorly; three pairs of short, faint glabellar furrows, first pair short, straight, second and third arcuate; dorsal furrow narrow, well defined at sides, fainter across front; occipital furrow narrow, deep and slitlike at sides, shallower across center; occipital ring narrow, flat, with a small median node; brim of medium width, descending at sides, but rising in front of glabella into a broad triangular median boss extending across the narrow marginal furrow (nearly blotting it out at center), onto the posterior part of border which is of medium width, flat at center, concave at sides, and upturned; anterior margin broadly curved. Fixed cheeks three-fifths width of glabella, slightly convex, very slightly upsloping; palpebral lobes medium, arcuate, back of midline of glabella but not on posterior third; faint curved ocular ridge extending to anterior corners of glabella; palpebral furrows shallow, narrow; posterior limb of medium width, same length as occipital ring. Free cheek a slender triangle with medium eye at inner angle; ocular platform of medium width, convex, strongly descending; marginal furrow narrow, well defined; border narrow, flat, horizontal, with a short pointed anterior projection and a medium-length, slender flat genal spine. Facial suture cutting anterior margin well out at sides, curving out and back to marginal furrow, then running straight in to and curving around palpebral lobes, thence curving out and back to cut posterior margin well within genal angle.

Thorax of 19 narrow segments; axis low, narrower than pleural lobes; pleural segments crossed by broad and very shallow pleural furrows and ending in short pointed falcate terminations.

Pygidium triangular in shape; axis wide, strongly convex, with nearly parallel sides, extending to posterior margin with broadly rounded end, divided by two narrow furrows into two segments and a broad terminal portion; dorsal furrow obsolete; pleural platforms approximately one-third width of axis, slightly convex, downsloping; no interpleural grooves or segments seen; no marginal furrow or border seen.

Outer surface coarsely granulated; inner surface punctate with heavy anastomosing veins crossing ocular platform and brim.

Discussion.—This species is represented by two immature and three adult cranidia, several free cheeks and a pygidium. All are quite fragmentary but are identifiable specifically. The largest cranidium, though very broken, is interesting as it shows the size which can be reached by the species and also the stronger glabellar furrows in the larger individual. The two immature cranidia are important also. They agree in every feature with the adults except that the median boss is not developed yet. These cranidia are about 3 mm. in length.

McKee and Resser (1945) demonstrated that both the shale and sand specimens come from the same stratigraphic position and not as stated by Walcott in his description. At this time Resser chose U.S.N.M. No. 61574, a complete carapace in shale, as the lectotype. This specimen is somewhat flattened, but except for this distortion is obviously the same species as the sand specimen.

Hypotypes.—U.S.N.M. Nos. 115887-115892.

Formation and locality.—Middle Cambrian, Arrojos formation, 801-O.

ALOKISTOCARE MODESTUM Lochman, new species

Plate 27, figures 11-16

Cranidium quadrate, average specimen 6 mm. across the eyes by 6 mm. in length; glabella short, conical, length and width practically same, with broadly rounded front, convexity low, highest posteriorly to quite low anteriorly; three pairs of medium glabellar furrows, first pair short, straight, second and third longer, arcuate; dorsal furrow well defined; occipital furrow broad, deep at sides, shallow across center; occipital ring triangular, flat, with a small median node; brim of medium width, slightly convex, descending at 45°; marginal furrow broad, extremely shallow, interrupted at center by a very low median bulge which starts on posterior edge of brim and is elongate forward to touch the border; border slightly over half the width of brim, slightly convex, descending; anterior margin evenly rounded. Fixed cheeks over one-half but not quite two-thirds width of glabella, very slightly convex, very slightly upsloping; palpebral lobes of medium size, strong, curved, situated just back of midline of glabella; palpebral furrow wide, shallow; ocular ridge wide, low; posterior limbs nearly same length as occipital ring, crossed by a broad, shallow marginal furrow. Free cheek of medium width, elongate, with medium-sized eye at inner angle; ocular platform about medium width, slightly convex, steeply sloping; marginal furrow very shallow, nar-

row; border narrow, slightly convex, horizontal with a short pointed anterior projection and a short flat genal spine. Facial suture cutting anterior margin well out at sides, curving out to marginal furrow, then curving back and into and around palpebral lobes; thence running diagonally out and curving back to cut posterior margin within genal angle.

Thorax and pygidium not known.

Outer surface covered thickly with fine granules; inner surface appearing smooth.

Discussion.—This species is represented by eight cranidia and three free cheeks in the collection from locality 801n. The granulated outer surface is quite well preserved.

The species is most similar to the genotype, *A. subcoronatum* (Hall and Whitfield) differing from it mainly in the weaker development of the median bulge and the steeper descent of the border. In the genotype the border is essentially horizontal in position.

The single small cranidium (4 mm. in length) from the Langston formation of Idaho, identified by Resser as *Inglefieldia idahoensis,* is clearly a species of *Alokistocare,* and is very close to *A. modestum,* showing the same type of low median bulge. Additional and better-preserved specimens from both localities may demonstrate the synonymy of the species, but at present the holotype of *A. idahoensis* (Resser) (not *A. idahoense* Resser) differs from *A. modestum* Lochman in having the brim and border of practically the same width, and the border apparently somewhat more convex.

Types.—Holotype: cranidium, U.S.N.M. No. 115897; paratypes: cranidia, U.S.N.M. Nos. 115898, 115899, 115901c,d; free cheeks, U.S.N.M. Nos. 115900, 115901a,b.

Formation and locality.—Middle Cambrian, Arrojos formation, 801n.

ALOKISTOCARE cf. A. MODESTUM Lochman, new species

Plate 27, figures 9, 10

Three cranidia in the collection from locality 800a are given this tentative identification. None is very well preserved, the surface being weathered and the edges of the cranidia broken. The measurements seem to fit *Alokistocare* rather than *Kistocare.* The specimens appear to resemble *A. modestum* Lochman, new species, in the weak development of the median bulge and in the width and proportions of the brim and border. They do show, however, three pairs of well-developed glabellar furrows, a feature more characteristic of *Kistocare tontoensis* (Resser) of this same fauna. The author considers that

there may be a possibility that these cranidia are actually the same as those representing that species, but that poor preservation or some slight distortion has blurred their true characters. Therefore their identification as *Alokistocare modestum* Lochman, new species, should remain tentative.

Figured specimens.—U.S.N.M. Nos. 115894, 115895.

Formation and locality.—Middle Cambrian, Arrojos formation, 800a.

Genus ALOKISTOCARELLA Resser, 1938

ALOKISTOCARELLA MEXICANA Lochman, new species

Plate 27, figures 1, 2

Cranidium nearly quadrate; glabella broadly conical, rounded in front, slightly convex, with greatest convexity posterior, sloping down rapidly anteriorly; three pairs of faint glabellar furrows, first pair short, straight, second short, curved, third longer, arcuate, all furrows mainly distinguished by absence of granules; a medium-wide, well-defined dorsal furrow around glabella; occipital furrow narrow, slitlike at sides, shallow and wider across center; occipital ring of medium width, slightly convex; brim of medium width, convex, regularly downsloping; marginal furrow broad, shallow, clear at sides, becoming fainter across center; border three-fourths width of limb, flat, slightly downsloping, with a low, transversely oval bulge on median line in posterior half; anterior margin evenly curved. Fixed cheeks not quite two-thirds width of glabella, slightly convex and slightly downsloping; palpebral lobes just under medium, curved, slightly posterior to midline of glabella; palpebral furrow shallow, well defined; a broad, low, gently curved ocular ridge; posterior limbs narrow, same length as occipital ring, crossed by a medium-wide, deep marginal furrow. Free cheek not known. Facial suture cutting anterior margin well out at sides, curving out and back to marginal furrow, then running diagonally into and curving around palpebral lobes, thence curving first nearly straight out, then sharply back to cut posterior margin within genal angle.

Thorax and pygidium not known.

Outer surface thickly covered with medium-sized granules, except the smooth furrows and bulge on the border. Inner surface not known.

Discussion.—This species is represented by three cranidia 6½ mm. in length and a fourth one somewhat smaller from locality 801n, and a broken, deeply weathered cranidium, 7 mm. in length, from 800c.

It is interesting to find a species of *Alokistocarella* in the Mexican

material so close in all features to the genotype from the southern Appalachian region. It may be distinguished from *A. typicalis* Resser by the descending nature of the narrow border as contrasted to the distinct upcurve in the latter species. The Mexican species also has a less convex glabella and a shallower dorsal furrow. It is doubtful how much importance should be put on these features, because all the types and duplicates of *A. typicalis* are internal molds in a punky yellow sandy leached limestone. Such preservation tends to emphasize the depth of furrows and convexity of glabella.

A. mexicana differs from *A. brighamensis* Resser in the flat horizontal border of the latter species, but as the types are crushed and flattened in shale this may be only a feature of preservation.

The preservation of *A. typicalis* and *A. brighamensis* fails to show the low median bulge although some cranidia of the former species have a suggestion of it.

Types.—Holotype, U.S.N.M. No. 115884; paratypes, U.S.N.M. Nos. 115885a, b, 115886.

Formation and locality.—Middle Cambrian, Arrojos formation, 800c, 801n.

Genus KISTOCARE Lochman, 1948

KISTOCARE CORBINI Lochman

Plate 28, figures 12-22

Kistocare corbini Lochman, Journ. Paleontol., vol. 22, p. 463, pl. 70, figs. 1-6, 1948.

Original description.—"Cranidium subquadrate, largest specimen 8 mm. across the eyes by 7 mm. in length; glabella conical, slightly longer than wide, broadly rounded in front, convexity low, regular; three pairs of moderately deep glabellar furrows, first pair short, diagonal forward, second short, straight, third pair longer, arcuate; dorsal furrow narrow, deep at sides, shallow across front; occipital furrow narrow, deep at sides, broad and very shallow across center; occipital ring of medium width, slightly convex, with a small median node; brim and border nearly subequal, brim just a bit narrower, flat, sloping downward; marginal furrow narrow, shallow, becoming faint on median line; border narrow, flat, nearly horizontal (very slight descent can be seen); anterior margin evenly curved. Fixed cheeks slightly over one-half width of glabella, slightly convex, very slightly upsloping; palpebral lobes wide, raised, medium size, on posterior one-third line of glabella; palpebral furrow broad, shallow; ocular ridge wide, prominent, strongly curved; posterior limbs narrow, same

length as occipital ring, crossed by a broad, well-defined marginal furrow. Free cheek narrow, elongate, with medium eye at inner angle; ocular platform of medium width, one and one-half times the border, flat, gently descending; marginal furrow narrow, shallow; border narrow, very slightly convex, almost horizontal, with a slender pointed anterior projection and a short, slender genal spine. Facial suture cutting anterior margin far out at sides, curving out to marginal furrow, then curving back and into and around palpebral lobes; thence running diagonally outward and curving abruptly back to cut posterior margin within genal angle.

"Thorax not known.

"Pygidium broadly transverse; axis wide, strongly convex, very slightly tapered to a broadly rounded end, apparently extending to posterior margin, divided by two broad faint furrows into two narrow segments and a long terminal portion; dorsal furrow obsolete; pleural platforms slightly more than half the width of axis, flat, then steeply descending, two very faint narrow interpleural grooves distinguishable; marginal furrow obsolete; no border distinguishable; a long, narrow facet turns abruptly back at a 45° angle so that the lateral and posterior margins form a single gentle curve.

"Outer surface covered thickly with fine granules; inner surface apparently smooth."

Discussion.—This species is represented by a number of cranidia, three free cheeks, and a pygidium in the collection from locality 800c and six cranidia from locality 801n. The best-preserved specimens are unfortunately the smaller cranidia so that the holotype and best paratypes are about 3 mm. in length. Most of the larger cranidia are broken and crushed and so do not afford a perfect picture of the species.

This species differs from *Kistocare tontoensis* (Resser) in the somewhat wider proportion of the brim to the border, and the nearly horizontal position of the border.

Types.—Holotype, U.S.N.M. No. 115923; paratypes: cranidia, U.S.N.M. Nos. 115926-115928, 115931-115934; free cheeks, U.S.N.M. Nos. 115924, 115925; pygidium, U.S.N.M. No. 115929; unfigured paratype, U.S.N.M. No. 115930.

Formation and locality.—Middle Cambrian, Arrojos formation, 800c, 801n.

KISTOCARE TONTOENSIS (Resser)

Plate 28, figures 26-31

Parehmania tontoensis RESSER, Carnegie Inst. Washington Publ. 563, p. 207, pl. 24, fig. 22, 1945.

Original description.—"A cranidium has been segregated to represent this species. It occurs in micaceous sandstone and is coated with limonite.

"Glabella occupies a little more than half cranidial length; tapers normally to truncated front; several pairs of furrows and a keel faintly outlined. Brim consists of the usual rim and preglabellar area. In certain light, rim appears to be wider than preglabellar area, whereas light from the other direction gives the opposite impression. This indicates width and shallowness of anterior furrow. Fixigenes equal to about three-fourths glabellar width. Eyes situated behind central point, so that eyelines swing backward sharply. Postero-lateral limbs narrow and small. Owing to slight compression, the convexity cannot be determined, although the specimen shows considerable relief both as a whole and in its various parts.

"Measurements: Holotype (cranidium), length 5.5 mm., width at eyes 6.2 mm., length of glabella 3.4 mm., anterior width of glabella 2.2 mm., width at base of glabella 2.5 mm."

Supplementary description.—Cranidium subquadrate; glabella conical, very slightly longer than wide, front broadly rounded, convexity low, regular; three pairs of moderately deep glabellar furrows with a pair of faint anterior pits which may represent another vestigial pair; first pair short, straight, second and third longer, arcuate; dorsal furrow narrow, well defined; occipital furrow broad, deep at sides, very shallow across center; occipital ring of medium width, flat with a small median node; brim narrow, slightly less than border in front of glabella, flat, gently descending; marginal furrow broad, quite shallow on outer surface, deeper on internal mold (as in holotype), with suggestion of a very slight median inbend; border narrow, slightly convex, continuing downslope of brim; anterior margin evenly curved. Fixed cheeks slightly over half the width of glabella, slightly convex, almost horizontal; palpebral lobes wide, raised, of medium size, on posterior one-third line of glabella; palpebral furrow broad, shallow; ocular ridge wide, prominent, strongly curved; posterior limbs narrow, same length as occipital ring, crossed by a broad, well-defined marginal furrow. Free cheek not known. Facial suture cutting anterior margin far out at sides (on line with outer third of fixed cheek), curving out to marginal furrow, then diagonally back and into and

around palpebral lobes; thence curving outward and strongly backward to cut posterior margin within genal angle.

Thorax and pygidium not known.

Outer surface thickly covered with fine granules; inner surface not known.

Discussion.—This species is represented by five cranidia, most of them partly broken but they check in every detail available with the sandstone-mold holotype from the Grand Canyon region. The supplementary description is based primarily on the holotype cranidium with the character of the outer surface of the test added from the hypotypes. It should be noted that the original description erred especially in the width of the fixed cheeks.

This species was described by Resser in 1945 as *Parehmania tontoensis* but it differs from *Parehmania* Deiss, 1939, in the following diagnostic features:

1. The palpebral lobe in *Parehmania* is just back of the midline of the glabella, not on the posterior one-third line.
2. The fixed cheeks in *Parehmania* are definitely one-half width of glabella and not more.
3. The posterior limbs in *Parehmania* are slightly less than the length of the occipital ring.

It is interesting to find this Arizona species in the Mexican section as its faunal association in both localities is the same. It apparently maintains the same stratigraphic position throughout this region.

Hypotypes.—U.S.N.M. Nos. 115937-115940.

Formation and locality.—Middle Cambrian, Arrojos formation, 800a.

Family CREPICEPHALIDAE Kobayashi, 1935

Genus KOCHASPIS Resser, 1935

KOCHASPIS COOPERI Lochman, new species

Plate 25, figures 33, 34

Cranidium and free cheek not known.

Thorax not known.

Pygidium transversely rectangular; axis of medium width, strongly convex, tapering posteriorly, with a low extension on the border, divided by narrow furrows into three segments and a terminal portion; dorsal furrow narrow, shallow, extending all around axis; pleural lobes two-thirds width of axis; pleural platforms slightly convex, tapering posteriorly, divided into four segments by broad, shallow interpleural grooves which curve backward and fade into base of spines; a narrow,

flat border delimited only along posterior margin, laterally forming bases of spines; at posterolateral corners a slender flat spine leaves border and curves very slightly inward for a distance slightly more than length of body of pygidium; lateral margin from anterior to tip of spines is gently convex; posterior margin moderately convex. Outer surface thickly covered with fine granules.

Discussion.—Eight pygidia from locality 801k include a number which are broken and small, but several fairly well preserved. No cranidium can be associated with them. They definitely belong to *Kochaspis* but are not like any previously described species. It is most like the pygidia assigned to *K. dispar* Resser (*K. maladensis* Resser) but differs from them in the slight convexity of the pleural platforms and the direction of the marginal spines. In the holotype pygidium, chosen because of its completeness, the convexity is probably somewhat lower than that attained in the larger adult specimens.

Types.—Holotype, U.S.N.M. No. 115853; paratypes, U.S.N.M. Nos. 115854, 115855.

Formation and locality.—Middle Cambrian, Arrojos formation, 801k.

KOCHASPIS aff. K. CELER (Walcott)

Plate 24, figures 27-30

Crepicephalus celer Walcott, Smithsonian Misc. Coll., vol. 67, No. 3, p. 101, pl. 11, fig. 2, 1917.

Ptychoparia clusia Walcott (the cranidium), Smithsonian Misc. Coll., vol. 67, No. 3, p. 85, pl. 11, fig. 3, 1917.

Kochaspis celer (Walcott) Resser, Smithsonian Misc. Coll., vol. 93, No. 5, p. 37, 1935.

Original description.—"Glabella a little more than two-thirds as long as the cranidium, quite strongly elevated along a subacute medial ridge which disappears gradually toward the front; outline trapezoidal, the broadly rounded anterior extremity not more than half as broad as the base; dorsal furrows rather wide, deeply impressed, converging quite rapidly anteriorly and rounding sharply into the more shallow, transverse anterior furrow; glabellar furrows also broad and deep, though not persistent across the crest; posterior pair inclined to the axis of the shield at an angle of a little more than 45°, almost completely isolating the tumid posterior lobe; medial pair neither so broad nor so deep as the posterior and nearly at right angles to the axis; anterior pair a little shorter than the medial, slightly inclined toward the front and placed nearer to the medial pair than to the anterior furrows; occipital groove broad and deep, completely dissecting the crest of the

glabella, very slightly sinuous; occipital ring rather narrow, expanded medially, obtusely angulated at the medial posterior margin, and bearing a rather prominent median node. Fixed cheeks plump and quite wide, the distance from the palpebral lobe to the dorsal furrow a little more than half the width of the medial portion of the glabella; postero-lateral lobe narrow and probably extended laterally; posterior furrow conspicuously broad and deep, its inner terminus in line with both the occipital furrow and ring; posterior margin narrow and sharply elevated. Palpebral lobe short, narrow, crescentic, set opposite the lobe between the posterior and medial furrows. Palpebral ridge rather prominent, cordate, arching across the fixed cheeks and intercepting the dorsal furrows directly in front of the anterior glabellar furrows. Frontal limb rather narrow, inflated laterally, gently declining medially. Frontal border wider medially than the limb, sharply upturned. Facial sutures imperfectly preserved.

"Exterior surface very finely and closely granulated or roughened by an irregular pitting with broken, depressed ridges that give the effect of obscure granulation.

"Pygidium rudely quadrate in outline exclusive of the posterior constriction, the lateral margins approximately parallel to the axis; anterior margin broken by the forward curve of the axial lobe; posterior margin very broadly and deeply insinuated. Axial lobe large and coarse, broadly conic in outline, acutely tapering posteriorly; axial annulations probably very distinct in perfectly preserved individuals, including apparently 6 component segments and a terminal section. Pleural lobes flexuous, irregular in outline, the anterior lateral margin an obtuse right angle; pleural furrows following the same general direction as the outer margin but less angulated, disappearing abruptly along an imaginary arc of about 180°; extremities of pleural lobes produced into cuneate appendages, acutely tapering."

Discussion.—This species is represented by four immature cranidia, 1.5 mm. to 2 mm. in length, and several small adult cranidia, none of which are complete enough to warrant positive specific identification. The determinable details of the adult cranidia suggest close affinities with *Kochaspis celer* (Walcott). This, unlike most species of *Kochaspis,* shows the same type of narrow brim and border with a similar slope and convexity. However, the incompleteness of the Mexican material does not warrant positive identification with this species or description as a new species.

Several of the cranidia show features of immaturity, as (1) in the smallest cranidium an additional pair of anterior glabellar furrows appears as small pits, and (2) the glabella has a square rather than

rounded front as it is just transitional from the straight-sided rectangle of the protaspid stage to the conical type of glabella of the adult. Several cranidia of *Kochaspis celer* (Walcott) show this feature through a length of 3-4 mm.

Figured specimens.—U.S.N.M. Nos. 115824, 115825, 115826, 115827.

Formation and locality.—Middle Cambrian, Arrojos formation, 802b.

KOCHASPIS? species undetermined

Plate 25, figures 23, 24

Three very incomplete and poorly preserved cranidia were obtained from two collections in the Puerto Blanco section. They show a strongly convex glabella, broader at base than long, with three pairs of deep, well-defined glabellar furrows, and the outer surface covered with coarse granules. The specimens are, however, so broken that even certain generic identification is not possible. The cranidia are noted because of their possible bearing on the position of the Lower–Middle Cambrian boundary, and because more complete material may demonstrate that they are the cranidia which should be associated with the pygidia of *Kochaspis cooperi* Lochman, new species.

Figured specimens.—U.S.N.M. Nos. 115852a, 115851.

Formation and locality.—Middle Cambrian, Arrojos formation, 801h, 801i.

Family KOOTENIDAE Resser, 1939

Genus KOOTENIA Walcott, 1889

KOOTENIA EXILAXATA Deiss

Plate 26, figures 1-20

Kootenia exilaxata Deiss, Geol. Soc. Amer. Spec. Pap. 18, p. 100, pl. 17, figs. 23-26, 1939.

Kootenia fragilis Deiss, Geol. Soc. Amer. Spec. Pap. 18, p. 100, pl. 17, figs. 18-20, 1939.

Kootenia infera Deiss, Geol. Soc. Amer. Spec. Pap. 18, p. 101, pl. 17, figs. 9-10, 1939.

Kootenia scapegoatensis Deiss, Geol. Soc. Amer. Spec. Pap. 18, p. 102, pl. 18, figs. 1-4, 1939.

Original description.—"Species known from several associated cranidia and pygidia.

"Cranidium similar to that of *Kootenia scapegoatensis,* but glabella relatively more slender, and fixed cheeks wider. Width of glabella one-

half length, including occipital ring. Dorsal furrows narrow, rounded, deep.

"Pygidium similar to that of *Kootenia erromena,* but slightly more transverse, and possesses a narrower and more parallel-sided axis."

Supplementary description.—Cranidium subquadrate in outline; glabella broad with parallel sides, rounding in at front; convexity relatively low but regular; suggestion of a faint short posterior pair of glabellar furrows; dorsal furrow narrow, well defined along sides and front, deepening to a small pit at anterolateral corners of glabella; occipital furrow broad, deep, especially at sides; occipital ring of medium width, convex, with a short, stout, upward-projecting median spine; brim a narrow, elongate, steeply sloping triangle in front of fixed cheeks; marginal furrow narrow, shallow, continuous with dorsal furrow in front of glabella; border narrow, inner part flat and slightly wider at sides, outer part downcurved; anterior margin evenly curved. Fixed cheeks approximately one-half width of glabella, slightly convex, downsloping; palpebral lobes medium sized, curved, on posterior one-third line of glabella; ocular ridge broad, faint, slanting diagonally forward to anterior pit; palpebral furrow very faint; posterior limbs narrow, same length as occipital ring, crossed by a well-defined marginal furrow. Free cheek short, stout, with medium-sized eye at inner angle; ocular platform of medium width, slightly convex, downsloping; marginal furrow broad, shallow; border narrow, convex, horizontal, with a short, pointed anterior projection and a short, stout broad-based genal spine. Facial suture cutting anterior margin on midline of fixed cheeks, curving steeply back to marginal furrow, then running diagonally into and curving around palpebral lobes; thence running nearly straight out and curving sharply back to cut posterior margin within genal angle.

Associated hypostoma has edges poorly preserved, no border detected; a convex, semicircular posterior lobe separated from anterior lobe by a broad, very shallow semicircular furrow; anterior lobe an elongate, convex oval not defined from rest of body of hypostoma, with a crescent-shaped ridge at each posterior corner and a very shallow macula above it; anterior lobe merging anteriorly into the very wide lappets which appear to extend outward for some distance; anterior margin curved.

Pygidium transversely semicircular in outline; axis of medium width, strongly convex, only slightly tapered to rounded end which reaches border, divided into three definite, one faint segment, and a terminal portion by furrows becoming progressively fainter posteriorly; dorsal furrow narrow, faint, along sides; pleural platforms very

slightly less than width of axis, tapered posteriorly, regularly convex, sloping down to a shallow marginal furrow, divided into three and one-half segments by interpleural grooves becoming fainter posteriorly; border flat, narrow with six short spines on each side, anterior four lying opposite the three and one-half segments of pleural lobe; spines grade in size quite regularly but slightly from longest anterior pair to shortest posterior median pair; the two posterior pairs tend to curve up, the next two lateral pairs lie more horizontally, and the two anterior pairs tend to slope down slightly.

Outer surface covered by fine granules; inner surface apparently smooth.

Discussion.—This species is represented by a number of cranidia and pygidia and a few free cheeks and hypostoma in two collections. It is to be distinguished from all other described species by the combination of the following characters: In the cranidium, the low continuous curve of the glabella from front to back; the clear separation of the front of the glabella from the border by a well-defined marginal furrow; the width of brim at sides is slightly over one-half the width of the front glabella; and a short occipital spine is present. In the pygidium, the six pairs of relatively short marginal spines showing progressive increase in length from back to front; and the variable curvature and slope of the different pairs.

In studying the Mexican species, four species of *Kootenia* described by Deiss from the Damnation formation of Montana proved to be synonyms. Examination and measurement of the types of these species revealed them to be similar in all features of the cranidia and pygidia, and it became clear that they were simply different-size stages of the same species. Deiss's specimens are unfortunately all of the weathered surface-limestone type and are not well preserved. It is suggested that the specimens of *K. erromena* Deiss may also represent the same species, but the types are badly crushed and weathered and give somewhat different proportions.

The entire genus *Kootenia* is in need of careful revision. It appears that there has been a most unnecessary duplication of species. In addition, uncertainty as to the stratigraphic range of many of these species has rendered it useless as a zone fossil. However, careful attention to identification and stratigraphic position might well reveal it as a useful form, since it appears to have definite position in the Mexican section.

Hypotypes.—Cranidia, U.S.N.M. Nos. 115869-115872, 115874, 115881; pygidia, U.S.N.M. Nos. 115873, 115876-115878, 115882; hypostoma, U.S.N.M. No. 115875; free cheek, U.S.N.M. No. 115880.

Formation and locality.—Middle Cambrian, Arrojos formation, 800c, 801n.

Family PTARMIGANIDAE Resser, 1939

Genus ATHABASKIA Raymond, 1928

Examination and analysis of the genotypes of *Athabaskia* Raymond, 1928, and *Clavaspidella* Poulsen, 1927, show that the two genera, although closely related forms, are nevertheless distinct, and Resser (1935) was in error when he placed *Athabaskia* in synonymy with *Clavaspidella.* Raymond's choice of a type species was most unfortunate as his specimens are crushed and poorly preserved in a shale matrix. In fact, the specimens of *A. ostheimeri* Raymond and its probable synonym, *A. glacialis* Raymond, are possibly the most poorly preserved of all species belonging to the genus. The analysis of the two genera reveals that all the species assigned to *Clavaspidella* in the Cordilleran region actually belong to *Athabaskia.*

The cranidium of *Athabaskia* differs from that of *Clavaspidella* in the following points:

1. The glabella is of medium width with parallel sides in posterior half while that of *Clavaspidella* is narrow, with slightly concave sides.
2. The fixed cheeks are two-fifths, or slightly less than one-half, the width of glabella, while those of *Clavaspidella* are nearly two-thirds the width of the glabelia.

The pygidium of *Athabaskia* differs from that of *Clavaspidella* in the following points:

1. The axis is as wide as, or slightly wider than, the pleural platforms, while that of *Clavaspidella* is narrower.
2. The marginal furrow is obsolete, while it is present and distinct in *Clavaspidella.*

ATHABASKIA BELA (Walcott)

Plate 29, figures 1-10

Bathyuriscus belus Walcott, Smithsonian Misc. Coll., vol. 64, No. 5, p. 339, pl. 50, figs. 2, 2a-d, 1916.
Athabaskia bela (Walcott) Raymond, Amer. Journ. Sci., vol. 15, p. 311, 1928.
Clavaspidella bela (Walcott) Resser, Smithsonian Misc. Coll., vol. 93, No. 5, p. 20, 1935.

Original description.—"This species attains a larger size than either *B. anax* or *B. atossa,* and differs from them in minor details of the cranidium and pygidium. There is a faint trace of pleural furrows on the lateral lobes of the pygidium, whereas in *B. anax* and *B. atossa*

they are strongly defined. The variations from *B. belesis* are mentioned under that species.

"The largest cranidium has a length of 19 mm. and the largest pygidium has a length of 22 mm. and a width of 37 mm.

"An associated hypostoma of the *Bathyuriscus* form has the surface of its central portion marked by fine, sharp, irregularly concentric ridges. None of the cranidia or pygidia appear to have the outer surface of the test. They occur as casts in a very fine, chocolate-colored, arenaceous shale."

Supplementary description.—Cranidium elongate-oblong; glabella of medium width, straight sides in posterior half, then expanding evenly to the broad, slightly curved front, convexity low, but regular; four pairs of glabellar furrows, first and second pairs short and straight, at sides only, third short, slightly curved, fourth pair curving diagonally backward, not quite reaching center; dorsal furrow narrow, well defined to first glabellar furrow, then very shallow and nearly obsolete around front; occipital furrow well defined at sides only, quite shallow across center; occipital ring of medium width, triangular, flat, probably with a small median node; brim a narrow, elongate, downsloping strip in front of fixed cheeks; no marginal furrow; border a concave, triangular, vertical strip in front of each brim, with an extremely narrow convex edge which continues in front of glabella as a very narrow rim; anterior margin slightly curved. Fixed cheeks very narrow in front, expanding to slightly less than one-half width of glabella, slightly convex and upsloping; palpebral lobes arcuate, long, on posterior one-third line of glabella; palpebral furrow broad, well defined; no ocular ridge; posterior limb somewhat longer than occipital ring, narrow with ends directed backward, crossed by a broad shallow marginal furrow. Free cheek not known. Facial suture cutting anterior margin extremely far out, so that with a very slight curve it turns and runs straight into and curves around palpebral lobes; thence curving straight out, then abruptly back to cut posterior margin within genal angle.

Thorax not known.

Pygidium transversely semicircular in outline; axis of medium width and convexity, tapering posteriorly onto the border, divided by narrow furrows into four segments (last one faint), and a terminal portion; dorsal furrow narrow, only along sides; pleural platforms same width as axis, tapering posteriorly, moderately convex, downsloping, divided by narrow, well-defined interpleural grooves into four wide segments, crossed by faint pleural furrows just on inside portion; no marginal furrow; border of medium width, flat, forming a concave

upcurve from pleural platforms and crossed halfway by the interpleural furrows.

Outer surface apparently smooth except for a few narrow parallel ridges on border of cranidium and border of pygidium; inner surface not known.

Discussion.—This species is distinguished from all those described by the wide, strongly upturned border of the cranidium, and the four segments of the axis and quite faint development of the pleural furrows of the pygidium. On many specimens with poorly preserved outer surface they may appear to be missing.

The species is represented by three cranidia and a number of fragmentary pygidia in two collections. This is the second species from Mexico faunas which also occurs in the Gordon formation of Montana.

Hypotypes.—Cranidia, U.S.N.M. Nos. 115941, 115942, 115945; pygidia, U.S.N.M. Nos. 115943, 115946-115948.

Formation and locality.—Middle Cambrian, Arrojos formation, 800c, 801n.

ATHABASKIA MINOR (Resser)

Plate 31, figures 1-3

Clavaspidella minor Resser, Smithsonian Misc. Coll., vol. 97, No. 3, p. 9, pl. 1, figs. 45, 49, 1938.

Original description.—"A number of specimens in the Lakeview limestone evidently belong to *Clavaspidella.* This species is much smaller than any other thus far described; also, both the pygidial axis and the eye lobes are longer."

Supplementary description.—Cranidium elongate-oblong; glabella oblong, posterior half of medium width with parallel sides, expanding gradually anteriorly to a low rounded front; convexity low, regular; four pairs of short, shallow glabellar furrows, first pair slanting forward, second pair straight, third and fourth slanting backward; dorsal furrow of medium width, well defined all around glabella; occipital furrow broad and shallow; occipital ring of medium width, triangular, flat with a tiny median node; brim a narrow, gently descending rectangular area in front of each fixed cheek; no marginal furrow; border a very narrow, flat, slightly sloping band, narrowest on median line; anterior margin very slightly curved. Fixed cheeks approximately one-half width of glabella, slightly convex, horizontal; palpebral lobes long, wide, arcuate, on posterior one-third line of glabella; palpebral furrow wide, well defined; ocular ridge short, very faint; posterior limbs somewhat longer than occipital ring (crushed), crossed by a broad, shallow marginal furrow. Free cheek not known. Facial suture

cutting anterior margin far out, on line with dorsal furrow, curving back a short distance, then running diagonally inward to and around palpebral lobes, thence curving far out, then back abruptly to cut posterior margin within genal angle.

Thorax not known.

Pygidium transversely semicircular; axis of medium width, convex, tapering slightly to a broad pointed expansion extending onto the border, divided by four narrow, progressively fainter furrows into four narrow segments and a terminal portion; pleural platform very slightly wider than axis, slightly convex and descending gently, divided by four broad interpleural grooves which curve back onto the border; pleural furrows narrow, faint, fading out before reaching the border; no marginal furrow; border narrow, concave, upturned, posterior margin evenly curved.

Outer surface apparently smooth; inner surface also appears smooth.

Discussion.—The occurrence of this species in Mexican material affords another interesting tie with the Northwestern Middle Cambrian sections. It is represented by a small cranidium, and two somewhat larger pygidia, but none of the specimens is complete or very well preserved.

The redescription was written from the holotype and paratypes from the Lakeview limestone at Pend Oreille Lake, Idaho. The diagnostic characters of this species appear to be a combination of the following features:

1. In the cranidium the low convexity of the glabella and the flat, horizontal to very slightly descending position of the border, and
2. In the pygidium the narrow width and upturned position of the border and the faint impress of the pleural furrows.

Neither the long eyes, which are proportionately no longer than those of any other species of the genus, nor the small size, which simply means that only small specimens were found—features cited by Resser as diagnostic specific features—are regarded by the author as valid features.

Hypotypes.—Cranidium, U.S.N.M. No. 115988; pygidia, U.S.N.M. Nos. 115987, 115989.

Formation and locality.—Middle Cambrian, Arrojos formation, 800g.

Genus PTARMIGANIA Raymond, 1928

Considerable confusion has arisen as to the distinctions between *Ptarmigania* and *Dolichometopsis,* especially as a result of Resser's (1939) emendation of the genus. Consequently a complete restudy of the Langston material referred to both these genera and the plasto-

types of *Dolichometopsis resseri* Poulsen at the United States National Museum had to be made and points of interest were discovered.

The following distinctions can be recognized between the cranidia of *Dolichometopsis* and *Ptarmigania* when dealing with specimens at least 10 mm. or over in size. In *Dolichometopsis* (1) the palpebral lobes are large and (2) are situated on the posterior one-fourth line through the glabella, (3) the fixed cheeks are less than one-half and nearly one-third the width of the midline of the glabella, (4) the anterior end of the palpebral lobe and palpebral furrow run into and touch the dorsal furrow so that at this position the fixed cheek has no separate width, and (5) the anterior corners of the glabella tend to round in, the rounding becoming more pronounced with increase in size. In *Ptarmigania* (1) the palpebral lobes are just over medium size and (2) are situated on the posterior one-third line through the glabella, (3) the fixed cheeks are between three-fourths and three-fifths the width of the midline of the glabella, (4) there is always an appreciable width of fixed cheek crossed by a well-defined ocular ridge opposite the anterior end of the palpebral lobe, and (5) the anterior corners of the glabella always remain squared and generally expanded.

An examination of the small holaspid cranidia in the Langston material referred arbitrarily by Resser to either *Dolichometopsis* or *Ptarmigania,* the small cranidia from Greenland and those referred to *Dolichometopsis?* by Rasetti (1948) from Canada reveals that certain of the adult distinctions are lost. The anterior end of the glabella in both genera is expanded and somewhat squared, and the palpebral lobes in *Dolichometopsis* assume more nearly the one-third posterior line position. However, in none of the small Langston cranidia does the fixed cheek assume the narrower proportions and only in one form, described as *Dolichometopsis lepida* Resser, does the fixed cheek almost disappear opposite the anterior end of the palpebral lobe. Even in this form the palpebral furrow does not run right into the dorsal furrow as in *Dolichometopsis resseri* Poulsen. This general similarity of all the small cranidia of what I would consider to be only one genus, *Ptarmigania,* in the Langston material to the small cranidia of *Dolichometopsis* very probably was the original cause of the confusion. In view of the fact that all the large holaspid cranidia are definitely congeneric with *Ptarmigania rossensis* (Walcott), the author can see no reason why the smaller holaspid cranidia should not be considered to be *Ptarmigania* also. The similarity between the small holaspid cranidia of the two genera is interpreted as indicating that *Ptarmigania* is the early Middle Cambrian descendant of the late Lower Cambrian *Dolichometopsis.*

Concerning the pygidia of the two genera the following items should be noted: (1) There are no complete specimens in the Langston material at the United States National Museum in which cranidium, thorax, and pygidium are connected as Resser would imply (1939, p. 33). The specimen of *Dolichometopsis poulseni* Resser is just as figured on plate 5, figures 5, 6, consisting only of pygidium and seven broken thoracic segments. (2) The suite of type material of *P. rossensis* (Walcott) shows that in this species there is one well-developed anterior pair of marginal spines, almost always a second pair of spine nubbins opposite the second interpleural grooves, and on one specimen the inception of a third pair of spine nubbins opposite the third interpleural grooves. Such a condition indicates that marginal spines are inherent in the genus, and the forms described by Resser from the Langston show all the possible gradations up to four pairs of well-developed spines. The Langston material is thought to contain only three or four distinct species (one of them *P. rossensis* (Walcott)) and affords an excellent opportunity for a study of specific variation and growth stages within this genus.

(3) In view of the above-mentioned evidence from the specimens, the author agrees with Rasetti's opinion (1948, p. 20) that it is more plausible to accept Poulsen's assignment of a Lower Cambrian pygidium to his Lower Cambrian *Dolichometopsis* cranidium.

Genus PTARMIGANIA Raymond, 1928

PTARMIGANIA BISPINOSA Lochman, new species

Plate 22, figures 1-9

Cranidium subquadrate; glabella broad, elongate, with parallel sides and a very slight anterior expansion, rounded anterior corners, convexity low but regular; four pairs of glabellar furrows, first and second very short, straight, first very faint, third short, slightly curved, fourth longer, arcuate; dorsal furrow narrow, well defined all around glabella; occipital furrow narrow, well defined; occipital ring triangular, flat, with a small node on posterior midline; brim a narrow steeply sloping rectangle on sides; a faint narrow marginal furrow running into corners of glabella; border narrow, flat, widening slightly in front of brim, but rimlike in front of glabella. Fixed cheeks very narrow anteriorly, approximately one-third width of glabella on midline of palpebral lobes, very slightly convex, upsloping; palpebral lobes long, arcuate; palpebral furrow broad, well defined; ocular ridge obsolete; posterior limbs narrow, slightly shorter than occipital ring, lower than cheeks, crossed by a narrow well-defined marginal fur-

row. Free cheek too poor to describe. Facial suture cutting anterior margin far out at sides, curving out, then running straight back to and curving around palpebral lobes, then curving outward and straight backward to cut posterior margin within genal angle.

Hypostoma triangular with prominent broad convex lappets; a tumid elongate anterior lobe with a low, short ridge at each posterior corner and a shallow macula just anterior to it; posterior lobe apparently convex, narrow, semicircular, very poorly preserved; anterior border crushed, apparently regularly convex and downsloping; no marginal furrow; anterior margin a flat curve; lappets quite wide, extending hornlike at sides but full length not known.

Thorax not known.

Pygidium semicircular; axis wide, strongly convex, only slightly tapered to a broadly rounded end, extending nearly full length of pygidium, divided by three broad well-defined and one faint furrow into four segments and a terminal portion, first and second anterior segments with short stout axial spines and on third an axial node; dorsal furrow obsolete; pleural platforms practically same width as axis, moderately convex, downsloping steeply at sides, divided by broad, shallow interpleural grooves into four segments; where these grooves meet the border they form a shallow oval pit, otherwise no marginal furrows; flat, narrow border with four stout marginal spines on each side, lying opposite each pleural segment and directed nearly straight backward; length of spines not known.

Outer surface of smallest cranidium apparently smooth, but preservation poor; inner surface not known.

Discussion.—This species is described from a number of cranidia of varying sizes and a number of pygidia. Unfortunately, all the material occurs at one horizon and is crushed and the surface weathered so that the preservation is quite poor and no one specimen shows all features clearly and accurately.

The Mexican species is very similar to *P. rossensis* (Walcott) in the structure of the cranidium, showing only an occipital node rather than the usual strong spine. In the pygidium it appears that the four pairs of marginal spines were of medium length, and the species differs from all other described forms in the possession of two axial spines and the axial node on the third segment of the pygidium.

Types.—Holotype, U.S.N.M. No. 115760; paratypes: cranidia, U.S.N.M. Nos. 115764, 115765a; pygidia, U.S.N.M. Nos. 115761, 115762, 115765b; hypostoma, U.S.N.M. No. 115763.

Formation and locality.—Middle Cambrian, Arrojos formation, 801j.

Genus GLOSSOPLEURA Poulsen, 1927

GLOSSOPLEURA LEONA Lochman, new species

Plate 25, figures 1-21

Cranidium narrow, elongate-oblong; glabella of medium width, expanding very slightly forward to a wide, flatly curved front, low, regular convexity; four pairs of faint glabellar furrows, first and second short, slanting forward, third short, straight, fourth longer, diagonally backward; dorsal furrow narrow, well defined along sides to a small pit opposite first glabellar furrow, a faint suggestion continues to corner, but is obsolete across front (demarcation between glabella and border determined by a slight change in convexity); occipital furrow broad, well defined, deeper at sides; occipital ring of medium width, slightly convex; brim a narrow, flat, descending area in front of fixed cheeks, merging into border; no marginal furrow; border a narrow flat band continuing slope of glabella in front; anterior margin evenly curved. Fixed cheeks extremely narrow in front, slightly more than one-third width of glabella at midline of palpebral lobes, slightly convex and downsloping; palpebral lobes long, arcuate, situated on posterior third of glabella; palpebral furrow broad, well defined, running to dorsal furrow; ocular ridge faint, short; posterior limbs narrow, same length as occipital ring, crossed by narrow, well-defined marginal furrow. Free cheek narrow, elongate, with large eye at inner angle; ocular platform slightly convex, descending, narrow anteriorly, expanding posteriorly; a narrow, well-defined marginal furrow; border convex, narrow, downsloping, with a short anterior projection and a slender, medium-length genal spine. Facial suture cutting anterior margin on line with dorsal furrow, curving out and back and then straight into and around palpebral lobes; thence curving evenly out and back to cut posterior margin within genal angle.

Associated hypostoma subtriangular in outline; an extremely narrow border and marginal furrow along posterior half; marginal furrow deepening at each side; a narrow, slightly convex posterior lobe separated from anterior lobe by a broad, shallow furrow which joins marginal furrow at sides; anterior lobe tumid, broadly triangular, merging anteriorly into anterior margin and lappets, marked at each posterior corner by an elongate ridge with a broad, shallow macula just anterior to it; no anterior furrow or border distinguishable; lappets wide, length not known.

Thorax not known.

Pygidium semicircular; axis of medium width, moderately convex, tapering posteriorly to and onto marginal border, divided into five

or six narrow segments and a terminal portion by narrow, progressively fainter furrows; dorsal furrow very shallow, only along sides; pleural platforms approximately same width as axis, convex, descending steeply, divided by very faint interpleural grooves into four or five broad segments; no distinct marginal furrows; marginal border narrow, somewhat concave, descending slightly; posterior margin with a slight median inbend.

Outer surface covered thickly with fine granules with some narrow imbricating ridges on border of cranidium, free cheek, and pygidium; inner surface coarsely punctate.

Discussion.—This species is represented in several collections by a number of cranidia, pygidia, free cheeks, and hypostoma. The specimens in collections from localities 802b and 802c are medium-sized adults, but the rest of the specimens are quite small, a condition which has made comparison with the usually large specimens of *Glossopleura* difficult.

This species appears to differ from all described ones in (1) the gentle expansion and low convexity of the front of the glabella, and (2) the narrow, descending border of the pygidium. In fact, only two other species show a similar narrow border—*G. belesis* (Walcott), preserved in shale, and with the border apparently horizontal in position, and the paratype U.S.N.M. No. 62695 of *G. mckeei* Resser. On this specimen also the narrow border apparently lies in horizontal position and so is not comparable to the Mexican species. Attention should be called to the fact that the holotype of *G. mckeei* has a pygidial border of medium width and so could not represent the same species as the above-mentioned paratype. Two other paratypes referred to this species by Resser have also been misidentified—U.S.N.M. No. 62691 and U.S.N.M. No. 62690—the free cheeks and pygidium respectively of *Anoria tontoensis* (Walcott).

Types.—Holotype, U.S.N.M. No. 115830; paratypes: cranidia, U.S.N.M. Nos. 115832, 115833, 115839, 115843, 115845, 115847, 115848; pygidia, U.S.N.M. Nos. 115835, 115838, 115841, 115842, 115844, 115846, 115849; free cheeks, U.S.N.M. Nos. 115831, 115834; hypostoma, U.S.N.M. Nos. 115836, 115837.

Formation and locality.—Middle Cambrian, Arrojos formation, 802b, 802c, 801m, 801m', 801n.

GLOSSOPLEURA species [2]

Plate 31, figures 8-14

A number of specimens of a large species of *Glossopleura* was obtained from the shales in the upper part of the Arrojos formation in the Arrojos Hills. Some of the specimens are of the entire carapace, but all are unfortunately crushed and flattened in the shale, and, for some reason, the cephalon is poorly preserved. The absence of the free cheeks from most of the specimens suggests that they are actually molts of the animal. The cephalon and pygidium appear to be specifically similar to those of *Glossopleura mckeei* Resser from the Bright Angel shale of the Grand Canyon section. However, complete carapaces of the latter species show consistently seven segments in the thorax, regardless of size, whereas the Mexican species as consistently shows eight segments in the thorax. The author is at a loss to explain the true significance of this difference, as certainly the cephala and pygidia cannot be separated specifically. It must be admitted that the poor shale preservation in both groups of specimens makes it very difficult to judge the value of small specific features.

Figured specimens.—Cranidia, U.S.N.M. Nos. 115995, 116336; carapaces, U.S.N.M. Nos. 116333, 116334, 116335; pygidium and part of thorax, U.S.N.M. No. 115996.

Formation and locality.—Middle Cambrian, Arrojos formation, 800e, 800e′, 800f, 801m′.

Family ZACANTHOIDAE Swinnerton, 1915

Genus ALBERTELLA Walcott, 1908

ALBERTELLA PROVEEDORA Lochman, new species

Plate 23, figures 1-8

Cranidium oblong-elongate; glabella oblong, slowly expanding to a broadly rounded front, moderately and regularly convex; four glabellar furrows extending about one-third in on each side, first and second short, straight, third and fourth longer, arcuate; dorsal furrow well defined along sides, deepening to small pit at first glabellar furrow, very narrow and faint across front; occipital furrow broad and shallow; occipital ring of medium width, flat, probably a tiny posterior median node; brim a small rectangle in front of fixed cheek, sloping

[2] The collections studied by Dr. Lochman included some species also studied by Dr. Stoyanow. The latter regards the species as a new genus, *Sonoraspis*. Dr. Lochman, on the other hand, refers the specimens submitted to her to *Glossopleura*.—G. A. C.

steeply, then flattening out; no marginal furrow; border convex, narrow, rimlike; anterior margin a flat curve. Fixed cheek just a little more than one-third width of glabella, slightly convex, downsloping; palpebral lobes of medium length, posterior to midline of glabella, continuing forward into low, broad diagonal ocular ridges; palpebral furrow broad, shallow; posterior limbs of medium length and width with a very broad shallow furrow. Free cheek elongate, of medium width; medium-sized eye at inner angle; ocular platform of medium width, steeply sloping anteriorly, lower posteriorly; marginal furrow narrow, well defined; border of medium width, flat, with a short anterior projection and a medium-length, flat genal spine. Facial suture cutting anterior margin far out at side, curving around, then running straight back to and curving around palpebral lobes; thence curving out and back to cut posterior margin within genal angle.

Hypostoma roughly triangular in outline; anterior lobe oval, strongly convex, with a shallow crescentic furrow near posterior end; this furrow runs into a slitlike macula on each side; posterior to each macula is a low ridge; posterior lobe small, crescent-shaped, convex, separated from anterior lobe by well-defined furrow; marginal furrow very narrow; posterior border narrow, rimlike, marked by narrow ridges; anterior marginal furrow broad, very shallow; anterior border narrow, flat, extending laterally into flat lappets.

Thorax not known.

Pygidium semicircular; axis strongly convex, only slightly tapered, extending to border, divided by narrow shallow furrows into four segments, a faint fifth segment and a terminal portion; dorsal furrow obsolete, only as pits opposite first and second furrows; pleural platforms approximately one-half width of axis, tapering rapidly posteriorly, only three segments delimited by broad shallow interpleural grooves, anterior half segment and first segment extending laterally into a heavy marginal spine diverging out and back at 45°; posterior to spines a narrow, nearly flat border separated by a faint, shallow marginal furrow; posterior margin convex.

Outer surface covered thickly with fine granules; inner surface apparently smooth.

Discussion.—This species is represented by a small number of cranidia, pygidia, hypostoma, free cheeks, and associated protaspids in collections from one section. It is associated with the very widespread *Mexicella mexicana* Lochman. The matrix is a dirty limestone, and the restricted occurrence of *Albertella* in the various Cordilleran sections strongly suggests that this genus favored a muddy environment.

The species appears quite close to *Albertella bosworthi* Walcott both in the forward expansion of the glabella and the five segments of the axis of the pygidium. The pygidium of *A. proveedora* Lochman differs, however, in greater width of the pleural lobes in proportion to the axis, and the apparent absence of the median nodes on the axis. The cranidium differs in the medium length of the palpebral lobes. Those of *A. bosworthi* Walcott appear to have been somewhat longer even though the lengthening due to crushing of the shale matrix is discounted. This situation presents a problem which should receive further study as it appears that in all limestone specimens of the cranidium the palpebral lobes are of medium length, whereas in all shale specimens they appear to be larger.

Types.—Holotype, U.S.N.M. No. 115776; paratypes: cranidia, U.S.N.M. Nos. 115778, 115783; pygidia, U.S.N.M. Nos. 115777, 115781, 115782; free cheek, U.S.N.M. No. 115779; hypostoma U.S.N.M. No. 115780.

Formation and locality.—Middle Cambrian, Arrojos formation, 801i, 801k.

ALBERTELLA aff. A. PROVEEDORA Lochman, new species

Plate 23, figure 9

Remarks.—A single fairly well-preserved hypostoma which is identical in every feature with the hypostoma associated with *Albertella proveedora* Lochman, new species, occurs in the collection from locality 802a. However, as no cranidium or pygidium of *Albertella* have been obtained from this locality, the specific assignment must be considered tentative.

Figured specimen.—U.S.N.M. No. 115784.

Formation and locality.—Middle Cambrian, Arrojos formation, 802a.

Genus MEXICASPIS Lochman, 1948

MEXICASPIS DIFUNTOSENSIS Lochman, new species

Plate 22, figures 10-23

Cranidium oblong-elongate; glabella oblong, parallel-sided posteriorly, expanding very slightly anteriorly, moderately convex; four pairs of broad, shallow glabellar furrows, first and second short, straight, third and fourth longer, arcuate; dorsal furrow broad, shallow at sides, deepening into a small pit opposite first glabellar furrow, narrow and shallow around front; occipital furrow broad, well defined; occipital

ring of medium width, flat, triangular with a flat, short posterior median spine; brim a small square, steeply sloping area in front of fixed cheeks; narrow, shallow marginal furrow at sides merging into dorsal furrow; border narrow, flat, rimlike, crossed by several narrow ridges; anterior margin a flat curve. Fixed cheeks one-half width of glabella, slightly convex, horizontal; palpebral lobes of medium length, strongly curved, slightly back of midline of glabella; ocular ridge very faint in adult; palpebral furrow narrow, shallow; posterior limbs of medium length and width with a minute node on posterior margin near suture, and crossed by a broad shallow marginal furrow. Free cheek elongate, narrow; medium-size eye at inner angle; ocular platform convex, downsloping, narrow anteriorly, expanding posteriorly; marginal furrow shallow, wide, turning posteriorly; border of medium width, outer edge crossed by narrow ridges, flat, with a short, pointed anterior projection and a slender, medium-length genal spine. Facial suture cutting anterior margin far out at sides, curving out, then running straight back to and curving around palpebral lobes, thence curving out and back to cut posterior margin. Hypostoma subtriangular, expanded anteriorly into short, broad, downcurved lappets; anterior lobe oval, widening anteriorly, moderately convex, with a strong crescentic ridge on each posterior corner just below a shallow, slitlike macula; posterior lobe crescentic, of medium width, separated by well-defined furrow; narrow posterior marginal furrow; narrow, rimlike posterior border; anterior marginal furrow well defined through whole length; anterior border narrow, slightly convex.

Thorax not known.

Pygidium subquadrate; axis strongly convex, very slightly tapered, extending to border, divided by narrow furrows into four segments (posterior two faint) and a terminal portion; anterior first and sometimes second segment with a small median axial node; dorsal furrow broad, shallow; pleural platforms slightly narrower than axis, sloping gently down, divided into one anterior segment and triangular posterior area by one broad interpleural groove; anterior segment extending into a short, sharp marginal spine; pleural area extending posteriorly into another longer, heavier marginal spine, directed backward and somewhat laterally; flat border extending around back of pygidium, separated by a shallow marginal furrow which fades out across base of large marginal spine; posterior margin curving back from base of spine a short distance, then running straight across middle.

Outer surface covered with fine granules; inner surface minutely punctate.

Discussion.—This species is represented by a number of cranidia, free cheeks, hypostoma, and pygidia from the Difuntos Hills section. Some were broken freshly from the fine-grained limestone, and these specimens are the main types for the description; but there are many more specimens scattered over the surface of weathered slabs. On these the details of the structure are poorly preserved, and it should be noted that the posterior margin of the pygidium appears to be curved, whereas the two unweathered pygidia show the middle part actually to be straight.

The species is readily distinguished from *Mexicaspis stenopyge* Lochman, by (1) posterior part of glabella wider so that forward expansion appears less, (2) glabella moderately convex, (3) dorsal furrow in front of glabella and marginal furrow distinct on outer surface, (4) pygidium with broader proportions, and (5) the lateral direction of the posterior pair of marginal spines.

Types.—Holotype, U.S.N.M. No. 115766; paratypes: cranidia, U.S.N.M. Nos. 115768a,b, 115771, 115775c; pygidia, U.S.N.M. Nos. 115767, 115770, 115772, 115775a-c; hypostoma, U.S.N.M. No. 115769; free cheek, U.S.N.M. No. 115774.

Formation and locality.—Middle Cambrian, Arrojos formation, 802a, b.

MEXICASPIS STENOPYGE Lochman

Plate 23, figures 10-27

Mexicaspis stenopyge LOCHMAN, Journ. Paleontol., vol. 22, p. 455, pl. 69, figs. 1-11, 1948.

Original description.—"Cranidium oblong-elongate; glabella oblong, parallel-sided posteriorly, expanding moderately forward, slightly convex; glabellar and dorsal furrows practically obsolete on outer surface, well-defined on inner; four pairs of broad shallow glabellar furrows, first and second straight, very short, third arcuate, short, fourth arcuate, longer; dorsal furrow broad, shallow, deepening into small pit opposite first glabellar furrow, shallow across front of glabella; occipital furrow broad, shallow; occipital ring broadly triangular, flat, no median node; brim a narrow sloping rectangle in front of fixed cheek; marginal furrow of medium width, very shallow, merging with dorsal furrow; border narrow, very slightly convex, band-like; anterior margin a flat curve. Fixed cheeks one-half width of glabella, slightly convex, horizontal; palpebral lobes of medium length, slightly arcuate, situated a little back of midline of glabella; ocular ridge broad, very faint; palpebral furrow broad, only on inner surface; posterior

limbs of medium width and length, with a very broad shallow marginal furrow. Free cheek narrow, elongate, medium-size eye at inner angle; ocular platform narrow, flat anteriorly, becoming wider and steeply sloping posteriorly; marginal furrow broad, shallow; border of medium width, slightly convex, crossed by narrow ridges, with a short anterior projection and a long, slender genal spine. Facial suture cutting anterior margin far out at sides, curving out, then straight back to and around palpebral lobes, thence curving out and back to cut posterior margin within genal angle.

"Hypostoma subtriangular with broadly expanded anterior border and short, broad, curved lappets; anterior lobe oval, expanding anteriorly, moderately convex, with a prominent curved ridge at each posterior corner just below a shallow, slit-like macula; posterior lobe a small, convex crescent, separated from anterior lobe by a well-defined furrow which coalesces with the narrow posterior marginal furrow at the sides; narrow, rim-like posterior border; anterior border convex, narrow at center, expanding laterally into lappets, separated whole length from anterior lobe by anterior marginal furrow, deep and broad at center, shallow across lappets.

"Thorax not known.

"Pygidium elongate-oblong in outline; axis strongly convex, practically parallel-sided with bluntly rounded end, extending to border, divided into four or five segments and a terminal portion by furrows, anterior two broad and deep, others faint and narrow; a median axial node may be present on first two segments; dorsal furrows shallow; pleural platforms two-thirds width of axis, divided by one broad, deep interpleural groove into one broad anterior segment extending backward into a long slender marginal spine, and an unmarked triangular area continuing posteriorly into a short, stout marginal spine; the lateral margins converge posteriorly so that the posterior pair of spines are quite close together and extend straight back; a medium-wide flat border set off by a faint, shallow marginal furrow around posterior half; posterior margin very short, straight to slightly concave.

"Outer surface thickly covered with fine granules; inner surface minutely punctate."

Discussion.—This species is represented by a large number of cranidia and pygidia, and some hypostoma and free cheeks in collection from locality 801L, but the limestone matrix is coarse and crumbly and there has been some leaching by ground water so that the preservation of the surface and the spines is not good. The species has been chosen as the genotype because the greater numbers of specimens

afford a better concept of the size range to be expected. Several poorly preserved cranidia occur in the collection from locality 800d.

The species differs from *Mexicaspis difuntosensis* Lochman in (1) the narrower posterior part of the glabella, (2) the slight convexity of the glabella, (3) the very faint dorsal and marginal furrows on the outer surface, and (4) the narrower proportions of pygidium and backward direction of the posterior pair of marginal spines.

Types.—Holotype, U.S.N.M. No. 115785; paratypes: cranidia, U.S.N.M. Nos. 115787, 115792, 115794, 115796, 115798, 115799; pygidia, N.S.N.M. Nos. 115788-115790; hypostoma, U.S.N.M. Nos. 115786, 115793; free cheeks, U.S.N.M. No. 115791.

Formation and locality.—Middle Cambrian, Arrojos formation, 800d, 801L, 801ka.

Genus ZACANTHOIDES WALCOTT, 1888

ZACANTHOIDES aff. Z. HOLOPYGUS Resser

Plate 30, figures 11-17

Zacanthoides idahoensis WALCOTT (part), Smithsonian Misc. Coll., vol. 53, No. 2, p. 26, pl. 3, figs. 2-5, 10, 1908.

Zacanthoides holopygus RESSER, Smithsonian Misc. Coll., vol. 97, No. 12, p. 10, pl. 2, figs. 10-12, 1939.

Original description.—"At first it was thought this small species was merely a young stage of one of the larger forms, but careful sorting shows that such is not the case. *Z. holopygus* varies in length from less than one-eighth of an inch to more than 2 inches. As a whole this trilobite has a more even oval shape than most species of *Zacanthoides,* which is due to the fact that the thoracic terminations are relatively broader. It is the most common Spence shale species.

"*Z. holopygus* has rather large eyes, and the anterior facial suture diverges sharply, leaving rather long anterior angles. The pygidium is fused into a solid shield, including all marginal spines except the outer pair, the other spines being reduced to a serrated border. The long thoracic spine is not on the fifth but the last segment."

Discussion.—Seven poorly preserved and fragmentary specimens in shale from locality 800e′ and a poorly preserved cranidium, two pygidia, and a hypostoma in limestone from locality 801n are so tenatively identified. The specimens are all so poorly preserved that specific identification is doubtful at best. Enough of the structure of these parts can be made out, however, to suggest (1) that they all represent the same species, and (2) that the limestone cranidium is practically

identical with the uncrushed cranidia of *Z. holopygus,* and the pygidia resemble the pygidium of that species in the poor development of the marginal spines. Only a single large marginal spine, derived from the anterior segment, is present; the pleural lobes are extremely narrow, but the posterior margin is so poorly preserved in all specimens that its structure cannot be made out.

Attention should be called to the fact that a number of errors occur in Resser's original description, and the author wishes to make the following additions and corrections after a study of the type material. The serrate border of the pygidium has two small marginal spines on each side back of the big anterior spine. The large thoracic spine is on the eighth or next-to-last segment, as is well shown in a small paratype. Especially important is the fact that among the types the largest specimen showing the specific characters of *Z. holopygus* is the holotype carapace, 15 mm. in length. The 2-inch-long paratype carapace mentioned by Resser has a pygidium with four strong marginal spines as in *Z. idahoensis* Walcott. Therefore, it must be admitted that Walcott's early conclusion that these smaller forms represented the young of that species has not yet been disproved. Certainly all the Mexican material is small in size also. It would be most interesting to find what type of pygidium a large specimen from the same Mexican horizon would have.

Figured specimens.—Cranidia, U.S.N.M. Nos. 115984, 115979; carapace, U.S.N.M. No. 115985; pygidia, U.S.N.M. Nos. 115983, 115978; free cheeks, U.S.N.M. Nos. 115981, 115982.

Formation and locality.—Middle Cambrian, Arrojos formation, 800e′, 801c, 801n.

Family INCERTAE SEDIS

Genus ARELLANELLA Lochman, 1948

ARELLANELLA CABORCANA Lochman

Plate 29, figures 23-29

Arellanella caborcana Lochman, Journ. Paleontol., vol. 22, p. 460, pl. 70, figs. 22-26, 1948.

Original description.—"Cranidium nearly square, very slightly wider than long; glabella broadly conical—truncato-conical—with very broadly rounded front; convexity low; three pairs of glabellar furrows, well-defined on inner surface, faint on outer surface, in front of first pair on inner surface is an elongate slit at each side which may represent traces of another pair, first pair short, straight, second

pair longer, slightly curved, third longer, arcuate; dorsal furrow broad, shallow at sides, narrower and fainter across front; occipital furrow of medium width, deeper at sides, shallower across center; occipital ring of medium width, triangular (broken); brim of medium width, slightly convex, gently downsloping, merging smoothly into the narrow, flat, slightly upsloping border as marginal furrow is apparently obsolete; anterior margin evenly rounded. Fixed cheeks three-fifths width of glabella on midline, slightly convex, downsloping; palpebral lobes small, narrow, on midline of glabella; palpebral furrow narrow, faint; ocular ridge obsolete; posterior limb of medium width, same length as occipital ring, crossed by a broad, shallow marginal furrow. Free cheek of medium width, elongate, with small eye at inner angle; ocular platform of medium width, flat, gently downsloping; marginal furrow obsolete; border narrow, slightly convex, and downsloping with a long pointed anterior projection and a genal spine (broken). Facial suture cutting anterior margin on line with dorsal furrow, curving out to marginal furrow, then straight back to and around palpebral lobes; then running diagonally outward and back to cut posterior margin within genal angle.

"Thorax not known.

"Pygidium narrowly transverse, twice as wide as long; axis wide, slightly convex, only slightly tapered to broadly rounded end reaching nearly to posterior margin, divided by two very faint furrows into two narrow segments and a terminal portion; pleural platforms about one-half width of axis, convex, downsloping, divided by two very faint interpleural grooves into two narrow segments; no marginal furrow seen; very narrow border apparently present.

"Outer and inner surface of test may be smooth."

Discussion.—Five cranidia of varying sizes, a free cheek and three small pygidia are referred to this species. The holotype is the largest and best-preserved cranidium, although a peeled and somewhat worn specimen. The association of the free cheek and pygidia with the cranidia of this species rather than with those of *Arellanella sonora* Lochman, new species, will have to be considered open to question until more material is obtained. It is probable, in view of the general close relation of the cranidia of the two species, that the free cheeks and pygidia of the two would be very similar.

Types.—Holotype, U.S.N.M. No. 115961; paratypes: cranidia, U.S.N.M. No. 115965; free cheek, U.S.N.M. No. 115962; pygidia, U.S.N.M. Nos. 115963, 115964.

Formation and locality.—Middle Cambrian, Arrojos formation, 800a.

ARELLANELLA SONORA Lochman, new species

Plate 29, figures 15-19

Cranidium nearly square, slightly wider than long; glabella broadly truncate-conical, front broadly rounded, nearly straight; three pairs of glabellar furrows, very faint on outer surface, well defined on inner, first pair short, straight; second longer, slightly curved; third longer, arcuate; occipital furrow of medium width, deeper at sides, shallow across center; occipital ring of medium width, triangular, flat with a small median node; brim of medium width and convexity, descending; marginal furrow narrow, well defined at sides, becoming faint to obsolete across center; border narrower than brim, slightly convex, continuing descent of limb; anterior margin evenly rounded. Fixed cheek about three-fifths width of glabella, slightly convex and downsloping; palpebral lobes small, narrow, on midline of glabella; palpebral furrow narrow, faint; a very faint, narrow, curved ocular ridge; posterior limb of medium width, same length as occipital ring, crossed by a broad, shallow marginal furrow. Free cheek not known. Facial suture cutting anterior margin well out at sides, curving out to marginal furrow, then straight back to and around palpebral lobes; then running diagonally out and back to cut posterior margin well within genal angle.

Thorax and pygidium not known.

Outer and inner surface apparently smooth.

Discussion.—This species is represented by 12 or more cranidia, but most of them are small, immature specimens, 1 to 3 mm. in length, and the author hesitates to claim that they show all their specific characters well. This species differs noticeably from *A. caborcana* Lochman in the descending position of the border and the different proportions of the brim and border. Otherwise the two species are very close.

Types.—Holotype: cranidium, U.S.N.M. No. 115953; paratypes: cranidia, U.S.N.M. Nos. 115954-115957.

Formation and locality.—Middle Cambrian, Arrojos formation, 800a.

ARELLANELLA aff. A. SONORA Lochman, new species

Plate 29, figures 20-22

Three cranidia in a shale matrix are given this tentative identification. Two are so badly crushed and distorted as to be nearly unidentifiable, both generically and specifically. The third is an impression on which the fixed cheeks are clearly flattened and fractured, but it is

better preserved as to outline and some original convexity and suggests this identification.

Figured specimens.—U.S.N.M. Nos. 115958, 115959.

Formation and locality.—Middle Cambrian, Arrojos formation, 800b.

Genus CABORCELLA Lochman, 1948

CABORCELLA ARROJOSENSIS Lochman

Plate 29, figures 11-14

Caborcella arrojosensis LOCHMAN, Journ. Paleontol., vol. 22, p. 461, pl. 70, figs. 19-21, 1948.

Original description.—"Cranidium wider than long; glabella triangular with flatly curved front, base as wide as length, strongly convex with a steep slope to sides and in front; three moderately impressed glabellar furrows, first one short, straight; the second longer, diagonal; the third still longer, arcuate. Dorsal furrow broad, shallow; occipital furrow broad, sinuous, deep at sides; occipital ring broken; brim narrow, flat, steep in front of fixed cheeks, becoming nearly horizontal in front of glabella; marginal furrow narrow, shallow at sides, widening to a shallow pit on line with edge of glabella, then sloping up to center as a broad shallow furrow; border narrow, vertical, rounded on top, continuing down as a vertical doublure in front; anterior margin straight in center, curved slightly at sides. Fixed cheeks approximately three-fourths width of glabella, convex, sloping up to one-half height of glabella, then flattening; palpebral lobes small, situated just posterior to midline of glabella; prominent curved ocular ridge; palpebral furrow not seen; posterior limb triangular, width one-half the length, which is nearly same as occipital ring, directed backwardly at ends, crossed by a broad, shallow marginal furrow. Free cheek not known. Facial suture cutting anterior margin about halfway out, curving out to marginal furrow, then running straight up and back to and around palpebral lobes; thence curving outward and finally backward abruptly to cut posterior margin just within genal angle.

"Thorax and pygidium not known.

"Outer surface of cranidium smooth except for a row of coarse granules on brim and a few on fixed cheek following dorsal furrow; inner surface apparently smooth."

Discussion.—This species is represented by four cranidia from locality 800c. The surface is poorly preserved but otherwise they are fairly good. It should be noted that the peculiar structure of the

marginal furrow with a shallow pit on each side just in front of the dorsal furrow and then a rise of the surface of the furrow to the center could easily give the impression of an obscure or poorly developed median boss. It may actually be the inception of one, but as such, does not develop in the two known species into anything which could be considered a real boss.

Types.—Holotype: cranidium, U.S.N.M. No. 115950; paratypes: two larger cranidia, U.S.N.M. No. 115951, one small cranidium, U.S.N.M. No. 115952.

Formation and locality.—Middle Cambrian, Arrojos formation, 800c.

Genus INGLEFIELDIA Poulsen, 1927

INGLEFIELDIA IMPERFECTA Lochman, new species

Plate 30, figures 1-10

Cranidium subquadrate, very slightly wider across the eyes than long; glabella regularly conical, tapering to a broadly rounded front, convexity apparently low, regular; three pairs of moderately well-defined glabellar furrows, first pair short, straight, second and third longer, arcuate; dorsal furrow narrow, well defined around glabella; occipital furrow of medium width, deeper at sides, shallow across center; occipital ring of medium width, subtriangular, flat, with a small median node; brim of medium width, slightly convex, descending marginal furrow narrow, clearly defined; border of medium width, practically same as brim, flat, apparently horizontal; anterior margin evenly curved. Fixed cheeks two-thirds width of glabella on midline, slightly convex, horizontal or very slightly upsloping; palpebral lobes medium-sized, arcuate, almost on posterior one-third line of glabella; ocular ridge wide, well defined, curving forward to anterior corners of glabella; palpebral furrow narrow, shallow; posterior limbs narrow, apparently same length as occipital ring, crossed by a broad, shallow marginal furrow. Free cheek narrow, elongate with medium-sized eye at inner angle; ocular platform of medium width, flat, gently sloping; a narrow distinct marginal furrow; border narrow, flat with a short pointed anterior projection and a long slender genal spine. Facial suture cutting anterior margin well out at sides, curving out to marginal furrow, then diagonally into and around palpebral lobes; thence curving gently out and back before curving down abruptly to cut posterior margin within genal angle.

Associated hypostoma small, elongate oval, consisting of only an oval tumid central lobe separated from a narrow, convex border

posteriorly by a narrow, clearly defined furrow; anterior portion of hypostoma not preserved.

Thorax apparently of 14 segments; pleural lobes slightly wider than axis; axis moderately convex, pleural lobes only very slightly convex with short, stout falcate ends; pleural segments crossed by pleural furrows which are broad and shallow at inner part and deep and narrow at outer edge.

Pygidium small, triangular in outline, convex; axis moderately convex, apparently same width as pleural lobes, apparently extending nearly to posterior margin and only slightly tapered to a broad rounded end, divided by three broad shallow furrows into three segments and a terminal portion; pleural platform slightly convex, presence of any segmentation cannot be distinguished; presence of marginal furrow and border not known.

Outer and inner surface not known.

Discussion.—This species is represented by a large number of cranidia, several complete carapaces, a few free cheeks and pygidia from the shale of 800e and the compressed limestone of the overlying collection 800f. None of the specimens is well preserved and all have undergone some distortion, whether in shale or limestone. Consequently they are most unsatisfactory for study, and in determining their generic assignment measurements were taken on as many specimens as possible in order to get an idea of the probable true proportions.

This species was one of the first to be recorded from the Mexican Cambrian, being listed by Stoyanow (1942) as *Alokistocare.* At first glance the general shape of the cranidium and size of the palpebral lobes and curving ocular ridge do remind one of *Alokistocare,* but there is no trace of a median bulge. The above-mentioned detailed measurements reveal that the species differs markedly from *Alokistocare* also in the width of the fixed cheeks and the position of the palpebral lobes, as well as in the apparent length of the glabella and the regular convexity. In fact, these measurements place it in *Inglefieldia.*

Of the described species of *Inglefieldia* it appears to be closest to *I. discreta* Poulsen, as in that species the brim and border are practically the same width, but the brim is descending, whereas in *I. imperfecta* Lochman, new species, it appears to have been normally horizontal in position. The poor preservation of all the specimens makes it difficult to be sure about certain features of the carapace as indicated in the description.

Types.—Holotype, U.S.N.M. No. 115966; paratypes: cranidia, U.S.N.M. Nos. 115968, 115973, 115974, 115967, 115975, 115976;

pygidium, U.S.N.M. No. 115972; carapace, U.S.N.M. Nos. 115969, 115970, 115971.

Formation and locality.—Middle Cambrian, Arrojos formation, 800e, 800e′, 800f.

cf. INGLEFIELDIA IMPERFECTA Lochman, new species

Three medium-sized cranidia occur in the limestone of collection 800g along with four cranidia readily referred to *Inglefieldia imperfecta* Lochman, new species. These are incompletely preserved and all show clear evidence from the grain of the limestone of rather severe distortion, two obviously squeezed quite strongly laterally and the other in a diagonal direction. These cranidia appear to have fixed cheeks almost as wide as the glabella, very long posterior limbs and the facial suture anterior to the eyes running far outward to the marginal furrow. However, it is impossible to take any measurements even approaching accuracy on these specimens, and rough guesses give a combination of features quite unknown and unusual.

In their present preservation these three cranidia cannot be accurately identified. The tentative assignment is given on the supposition that they are just three very badly distorted cranidia of the species which can be identified from this collection. If, however, some of the features mentioned above are real, then their affinities may be with either the genus *Kochiella* or the species from the Langston formation identified by Resser as *Ehmaniella maladensis* Resser. Their very incomplete condition does not at present warrant their reference to either of these forms.

Described specimen.—U.S.N.M. No. 115977.

Formation and locality.—Middle Cambrian, Arrojos formation, 800g.

Genus MEXICELLA Lochman, 1948

MEXICELLA MEXICANA Lochman

Plate 24, figures 1-25

Mexicella mexicana Lochman, Journ. Paleontol., vol. 22, p. 457, pl. 69, figs. 12-22, 1948.

Original description.—"Cephalon slightly oval in outline; cranidium square in outline; glabella short, squat, conical with a straight front, moderately convex posteriorly and sloping down rapidly to low anteriorly, glabella only slightly longer than brim and border; three pairs of fairly well-defined glabellar furrows, first pair narrow slits, straight

or slightly slanted, set in from dorsal furrow; second pair diagonal, third pair arcuate, both on outer third of glabella; dorsal furrow well-defined, broad at sides, narrow across front; occipital furrow broad, deep at sides, shallow across center; occipital ring of medium width, expanding slightly at median line, with a small occipital node; brim wide, convex, with a low broad median bulge (not found in cranidia under 3 mm. in length); border semicircular, narrow, convex, barely distinguished in adult by a faint narrow marginal furrow on inner surface of test; anterior margin broadly rounded. Fixed cheeks wide, slightly less than width of glabella, flat; palpebral furrow very faint; palpebral lobes small, slightly curved, situated slightly in front of mid-line of glabella; ocular ridge prominent, curved; posterior limbs short, of medium width, with a narrow marginal furrow. Free cheek triangular in outline, steeply sloping in position with small eye at inner angle; ocular platform and border indistinguishable in small cheeks, but in larger ones a faint marginal furrow separates off a narrow border with a long pointed anterior projection and a squared genal angle with a minute node at outer corner. Facial suture cutting anterior margin half way out, curving gently out to edge of border, then back and straight into and around palpebral lobes; then curving out around and slightly in to cut posterior margin within genal angle.

"Thoracic segments narrow; axis rather strongly convex with a small median axial node apparently on each segment; pleural lobes one and one-half width of axis, flat near dorsal furrow, then moderately downsloping, with a short, backward turned point on end; pleural furrow shallow, broad; number of segments not known.

"Pygidium small, strongly convex longitudinally, transverse; axis wide, nearly flat, tapering rapidly, about two-thirds length of pygidium, crossed by one or two narrow furrows forming two narrow anterior segments and a wide terminal portion; dorsal furrow narrow, clear at sides, faint around end; pleural platforms narrower than axis, strongly convex, divided into two segments by narrow interpleural grooves; border of medium width, flat, nearly horizontal at sides, becoming vertical at back.

"Outer surface of pygidium, fixed cheeks and glabella sprinkled with small granules; the heavy anastomosing venation of inner surface radiating across brim shows through on outer surface of well-preserved specimens; inner surface coarsely punctate. In immature cranidia the outer surface is smooth. One free cheek shows four or five alternating low nodes and pits along base of ocular platform."

Discussion.—This species is extremely abundant in the earliest

Middle Cambrian faunal assemblages in the Mexican section. In collection 802a it is represented by cranidia ranging from the protaspid to small holaspid stage. One fragmentary cranidium reaches 13 mm. in length and two free cheeks in collection 801j would belong to cranidia 24 mm. in length. The great abundance of smaller cranidia suggests that they represent molts. The earliest holaspid stages more resemble the species *M. stator* (Walcott) in the apparent absence of the median bulge and lessened convexity of glabella.

One cranidium in collection 801k is much worn and abraded and the glabella appears low as in *M. stator*. The author believes that in this cranidium this feature is caused by the poor preservation and that it too is an individual of *M. mexicana*.

In the National Collection *Mexicella stator* (Walcott) is represented not only by the types in shale but also by some limestone specimens, slightly worn and distorted, but from the same section. There are also some cranidia in sandstone, labeled *Agraulos*, from U.S.N.M. loc. 150d, White Creek, Powell County, Mont., which show exactly the same specific features as *M. stator* and are here considered to represent the same species.

The two species appear to be very close, but can be distinguished by: (1) in *M. mexicana* Lochman the glabella is much more convex, and the curvature of the brim is stronger near the glabella, while in *M. stator* (Walcott) the curvature is gentler and more even and continuous; (2) in *M. stator* the fixed cheeks seem to be very slightly wider in proportion to the glabella than in *M. mexicana* but this feature may be due to slight mechanical flattening in the *M. stator* specimens.

Types.—Holotype, U.S.N.M. No. 115800; paratypes: cranidia, U.S.N.M. Nos. 115802, 115803, 115807-115810, 115812, 115813, 115815, 115820, 115829, 115817-115819; pygidia, U.S.N.M. Nos. 115801, 115804; thoracic segments, U.S.N.M. Nos. 115811, 115814; free cheeks, U.S.N.M. Nos. 115805, 115821, 115822.

Formation and locality.—Middle Cambrian, Arrojos formation, 800d, 801j, 801k, 801ka, 801L, 802a, 802b.

Genus PACHYASPIS Resser, 1939

PACHYASPIS DEBORRA Lochman, new species

Plate 25, figures 25-32

Cranidium subquadrate, a little wider than long; glabella broadly conical, tapering to a broadly rounded front, moderately convex; three pairs of glabellar furrows, first short and straight, second and third

longer, diagonal; dorsal furrow narrow, shallow; occipital furrow narrow, deep at sides, shallow across center; occipital ring narrow, flat, with a small median node; brim relatively narrow, slightly convex, continuing downslope of front of glabella; marginal furrow narrow, well defined; border narrow, widest at center, slightly convex, horizontal; anterior margin evenly rounded. Fixed cheeks one-half width of glabella, very slightly convex, slightly downsloping; palpebral lobes small, just in front of midline of glabella; palpebral furrow very narrow, faint; ocular ridge narrow, distinct, curving to just in front of first glabellar furrows; posterior limb of medium width, same length as occipital ring, crossed by broad, well-defined marginal furrow. Free cheek not known. Facial suture cutting anterior margin about halfway from center, curving back to marginal furrow, then running straight back to and around palpebral lobes; thence curving out and down to cut posterior margin within genal angle.

Thorax and pygidium not known.

Outer surface of test covered thickly with fine granules; inner surface not known.

Discussion.—This species is represented by about 12 small cranidia, none more than 5 mm. in length and one fragment of the glabella 7 mm. in length. The small size and indifferent preservation have made identification difficult, but the species appears to belong to *Pachyaspis.* There appears to be a slight difference among the cranidia in the slope of the fixed cheeks, some showing descent but others appearing practically horizontal. As the latter specimens appear slightly crushed, the author considers this feature to be due to preservation.

The species is close to *P. typicalis* Resser, differing from it mainly in the narrower and less steeply sloping brim and the narrower marginal furrow. The small Mexican cranidia also appear to have stronger glabellar furrows and stronger convexity of the glabella when compared with the larger holotype cranidium of *P. typicalis* Resser, but as certain of the smaller cranidia of the latter species show a more convex glabella and deeper furrows than the holotype, the author considers these differences to be caused by size and not to be specific differences.

Types.—Holotype, U.S.N.M. No. 115856; paratypes, U.S.N.M. Nos. 115857-115860.

Formation and locality.—Middle Cambrian, Arrojos formation, 802c.

Plate 26, figures 21-29

PACHYASPIS ISABELLA Lochman, new species

Cranidium subquadrate, average specimen 5½ mm. across the eyes by 5 mm. in length; glabella conical, slightly longer than wide, with a broadly rounded front, regular moderate convexity; three pairs of well-defined glabellar furrows, first pair short, straight, second and third longer, arcuate; dorsal furrow narrow, well defined; occipital furrow of medium width, deep at sides and shallow across center; occipital ring of medium width, flat with a strong posterior median node (almost a small spine); brim narrow, flat, steeply descending, slightly narrower than border in center; marginal furrow narrow, well defined; border convex, narrow, slightly descending; anterior margin almost straight. Fixed cheeks approximately one-half width of glabella, very slightly convex and downsloping; palpebral lobes small, lying slightly in front of midline of glabella; palpebral furrow narrow, shallow; ocular ridge narrow, strong, nearly straight; posterior limbs of medium width, about same length as occipital ring, crossed by a broad, well-defined marginal furrow. Free cheek narrow, elongate with small eye at inner angle; ocular platform of medium width, slightly convex, sloping; marginal furrow narrow, shallow; border narrow, convex, slightly sloping with a short pointed anterior projection and a short slender genal spine. Facial suture cutting anterior margin halfway out, making a long curve back to marginal furrow, then running straight into and around palpebral lobes; thence curving out and back to cut posterior margin within genal angle.

Thorax not known.

Pygidium small, triangular, moderately convex; axis of medium width, convex, tapering slightly to a broadly rounded end reaching nearly to posterior margin, divided by faint narrow furrows into three narrow segments and a long terminal portion; dorsal furrow very faint, at sides only; pleural platforms slightly narrower than axis, convex, steeply descending, divided by three narrow interpleural grooves into three and a half narrow segments and a terminal area; no marginal furrow; a very narrow, nearly vertical border.

Outer surface of test covered with fine granules; inner surface not known.

Discussion.—This species is represented by many small cranidia, several free cheeks and two pygidia (one unfortunately lost in cleaning) from collection 801m, and one broken cranidium from collection 801n. This is the first time the pygidium and free check have been obtained and described. It is surprising to find this second distinct

species of *Pachyaspis* associated with *Glossopleura leona* Lochman, new species, in collection 801m, whereas *Pachyaspis deborra* Lochman, new species, is associated with the same species of *Glossopleura* in collection 802c.

The species differs from *P. deborra* Lochman, new species, in the narrower and more steeply sloping brim and the somewhat wider border—the brim in front of the glabella being actually slightly narrower than the border on the midline. The border is also slightly sloping as contrasted to the horizontal position in *P. deborra*.

Types.—Holotype: cranidium, U.S.N.M. No. 115861; paratypes: cranidia, U.S.N.M. Nos. 115862, 115865, 115866, 115868; pygidium, U.S.N.M. No. 115864; free cheeks, U.S.N.M. No. 115863.

Formation and locality.—Middle Cambrian, Arrojos formation, 801m, 801n.

PACHYASPIS, species undetermined

Plate 24, figure 26

A single worn small cranidium 1.5 mm. in length occurs with *Mexicella mexicana* Lochman, new species, and *Mexicaspis difuntosensis* Lochman, new species, in collection 802a. The cranidium appears definitely to belong to *Pachyaspis* but it does not appear to belong to either *P. isabella* Lochman or *P. deborra Lochman.* The brim appears extremely narrow, steeply sloping, and the border is narrow, about $1\frac{1}{2}$ times the width of the brim and continues the same steep descent. This combination suggests a distinct and different species but the author is unwilling to describe a new species on a single cranidium. It is figured for future reference.

Figured specimen.—U.S.N.M. No. 115823.

Formation and locality.—Middle Cambrian, Arrojos formation, 802a.

PAREHMANIA, species undetermined

Plate 31, figures 5, 6

This identification is given to two poorly preserved cranidia from 800h, which the author cannot determine positively. The visible features indicate that the genus is certainly a member of the *Elrathia* stock, a group of trilobites which becomes prominent in the latter half of the Middle Cambrian. The genera of this stock are all characterized by having the fixed cheeks one-half the width of the glabella, the eyes and palpebral lobes of medium size and the glabella regularly conical in shape with nicely rounded front, and usually with three pairs of

short but clearly defined glabellar furrows. Variation in one or more of the other features determines various genera recognized in this stock, and to be absolutely certain of the identification all features must be determined.

In spite of the present generic uncertainty the recognition of a member of the *Elrathia* stock in the Tren dolomite is important as it indicates this formation is definitely younger faunally than the underlying Arrojos formation, and suggests a correlation with the *Elrathiella* zone in the lower part of the upper half of the Middle Cambrian.

The generic features which could be determined and which suggest *Parehmania* to the author are:

1. Palpebral lobes medium-sized, situated just back of midline of glabella.
2. Glabella conical, slightly longer than wide, with rounded front, convexity regular; three pairs of fairly well-defined glabellar furrows.
3. Fixed cheeks one-half width of glabella on midline.
4. Fixed cheeks horizontal.
5. Posterior limb unknown.
6. Brim, marginal furrow, border.

Figured specimens.—U.S.N.M. Nos. 115992, 115993.

Formation and locality.—Middle Cambrian, Tren dolomite, 800h.

Genus PROVEEDORIA LOCHMAN, 1948

PROVEEDORIA STARQUISTAE Lochman

Plate 21, figures 12, 22-28

Proveedoria starquistae LOCHMAN, Journ. Paleontol., vol. 22, p. 459, pl. 70, figs. 7-14, 1948.

Original description.—"Cranidium subquadrate, average specimen 5 mm. across the eyes by 4½ mm. in length; glabella tapered conical, longer than wide with front nearly straight across, convexity low, regular with a faint median ridge; three pairs of moderately deep glabellar furrows, first very short, slit-like, second longer, slightly curved, third longer, arcuate; dorsal furrow narrow, well-defined; occipital furrow wide, deep at sides, shallow across center; occipital ring of medium width, subtriangular, flat; brim of medium width, flat, moderately downsloping; marginal furrow narrow, shallow; border slightly narrower than brim, gently downsloping, practically flat but with a very shallow median groove; anterior margin evenly curved. Fixed cheeks two-thirds width of glabella, flat, slightly downsloping; palpebral lobes of medium size, situated almost on posterior one-third line of glabella; palpebral furrow narrow, faint; ocular ridge very narrow, faint, curving to anterior corners of glabella; posterior limbs

narrow, same length as occipital ring, crossed by a narrow, well-defined marginal furrow. Free cheek short, narrow, with medium eye at inner angle; ocular platform of medium width, slightly convex, downsloping; marginal furrow narrow, shallow; border narrow, flat, horizontal, with a short pointed anterior projection and a short flat genal spine. Facial suture cutting anterior margin well out at sides, curving back to marginal furrow, then running diagonally into and around palpebral lobes; thence running straight out before curving back abruptly to posterior margin within genal angle.

"Thorax and pygidium not known.

"Outer surface of test thickly covered with fine granules, passing into short imbricating ridges on border of cranidium and free cheek; inner surface not known."

Discussion.—This species is represented by seven cranidia and four or five free cheeks from locality 801i. The fauna from this collection is small, containing this species, one cranidium of *Albertella proveedora* Lochman, new species, and several cranidia referred to *Kochaspis?* species undetermined.

It is impossible to refer this species to any described genus, so, in spite of the limited amount of material, it was deemed best to erect a new genus for it.

Types.—Holotype, U.S.N.M. No. 115747; paratypes U.S.N.M. Nos. 115749, 115750, 115751a, 115752, 115748; unfigured paratypes, U.S.N.M. No. 115751.

Formation and locality.—Middle Cambrian, Arrojos formation, 801i.

Genus STROTOCEPHALUS Resser, 1935

STROTOCEPHALUS ARROJOSENSIS Lochman, new species

Plate 21, figures 29-34

Cranidium transverse, wider than long; glabella conical, with a broad nearly straight front, convexity low, regular; glabellar furrows very faint, posterior pair arcuate; dorsal furrow narrow, shallow, around glabella; occipital furrow medium wide, very shallow; occipital ring of medium width, flat, with a small median node; brim of medium width, convex, sloping at 45° angle; marginal furrow obsolete; border a little more than one-half width of brim, narrow, flat, slightly upturned (in small cranidia, 3 mm. in length, brim and border are subequal and separated by a narrow, just distinguishable marginal furrow); anterior margin regularly curved. Fixed cheeks almost same width as glabella on midline, very slightly convex, horizontal; palpebral

lobes arcuate, medium-sized, on posterior one-third line of glabella; palpebral lobes continuous with arcuate faint ocular ridges extending to very shallow pits at anterolateral corners of glabella; narrow, faint palpebral furrow; posterior limb narrow, little shorter than occipital ring, crossed by a shallow marginal furrow. Free cheek of medium width, elongate with medium eye at inner angle; ocular platform of medium width, flat; no marginal furrow; border flat, narrow with very short anterior projection, genal spine broken. Facial suture cutting anterior margin halfway out, curving far out to marginal furrow, then running diagonally into and around palpebral lobes; thence curving out and down to cut posterior margin within genal angle.

Thorax not known.

Pygidium not known.

Outer surface of cranidium covered thickly with fine granules; inner surface of largest cranidium showing coarse punctations with faint radiating venation across the brim, and the impress of the edge of the doublure about halfway forward on the brim.

Discussion.—The species is represented by four cranidia, three rather small, and several free cheeks. It appears to be fairly close to *Strotocephalus gordonensis* Resser, the genotype, differing from it only in the narrower brim.

The occurrence of a species of *Strotocephalus* in Mexico is interesting. The genotype is a member of the *Albertella* fauna of the Gordon formation of Montana, and while *Strotocephalus arrojosensis* Lochman occurs alone in 801h in the Puerto Blanco section, it is approximately 70 feet (21 m.) below 801i where *Albertella* first makes its appearance, and thus belongs to the same fauna and occurs at approximately the same position in both regions.

Types.—Holotype: cranidium, U.S.N.M. No. 115753; paratypes, U.S.N.M. Nos. 115754, 115755, 115756; unfigured paratype, U.S.N.M. No. 115757.

Formation and locality.—Middle Cambrian, Arrojos formation, 801h.

GENUS AND SPECIES UNDETERMINED 2

Plate 25, figure 22

Three small cranidia occur in collection 801h, which in spite of their very poor preservation appear to represent the same species and genus. They are, however, too small and too fragmentary to warrant a definite generic and specific determination. The best cranidium, only 1.25 mm. in length, is figured for future reference.

Figured specimen.—U.S.N.M. No. 115850a.

Formation and locality.—Middle Cambrian, Arrojos formation, 801h.

GENUS AND SPECIES UNDETERMINED 3

Plate 31, figure 7

A single broken small cranidium, estimated at 3 mm. in length when complete, shows features of the brim and border and a more strongly conical glabella with rather well-defined glabellar furrows, all of which suggest that it does not belong to the same species and probably not to the same genus as the two broken cranidia referred to *Parehmania,* species undetermined. However, the specimen is too fragmentary to afford even a single generic measurement with accuracy ; consequently it cannot be identified until more complete material from the same position has been obtained.

Figured specimen.—U.S.N.M. No. 115994.

Formation and locality.—Middle Cambrian, Tren dolomite, 800h.

Cf. MIDDLE CAMBRIAN TRILOBITES

Plate 31, figure 4

Three pieces of a thoroughly baked limy mud from Lista Blanca were collected, as each contained a very poorly preserved, but undeniable, trilobite fragment. These consisted of the distorted impression of a small cranidium, the impression of a fairly large broken free cheek, and the impression of what appears to be a medium-sized pygidium with a marginal spine, and a few thoracic segments.

None of the specimens is well enough preserved to warrant generic determination, but from their general appearance the author feels justified in suggesting that they represent a Middle Cambrian rather than a Lower Cambrian horizon.

Figured specimen.—U.S.N.M. No. 115990.

Formation and locality.—Middle Cambrian, 811a.

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EXPLANATION OF PLATES

Plate 1

Fig. 1.—North end of the Arrojos Hills. View looking to the southeast and showing the full section of the Arrojos formation. The dark hill on the right, of which only the base shows, is composed of the Cerro Prieto limestone. The lower Arrojos on the lower slope of the hill to the left is composed of somewhat heavy beds but the upper part is thin-bedded. The darker beds in the high part on the left is Tren dolomite. In the pass in the distance the volcanics of the Proveedora Hills are visible. The small hill on the extreme left is Tren dolomite.

Fig. 2.—Proveedora Hills. View of the Proveedora Hills taken from the high volcanic peak on the south side of the pass known as Puerto Blanco. The light-colored hills on the left side of the picture and nearly to the center are composed of Proveedora quartzite. The highest ridge in the center is the Cerro Prieto limestone and its west slope is the Buelna formation. The small fault shown in plate 4, figure 4, can be seen on this slope. The Arrojos formation occupies the deep valley between the two high ridges. The divide or saddle is visible just to the right of the high ledge that protrudes on the east slope of the ridge formed of the Cerro Prieto limestone. *Albertella* occurs on the slope between the high ledge and the divide. On the opposite slope near the base occur *Mexicaspis* and *Glossopleura*. *Kootenia* occurs about halfway up the slope. The Tren dolomite forms the massive hill on the right. On the extreme right margin of the picture can be seen the lower slope of a small hill of white dolomite which is Tren dolomite altered to marble.

Plate 2

Aerial view of the Proveedora Hills (locality 801) showing two prominent ridges and saddle in middle of valley between them. The high ridge on the west side of the saddle is composed of Cerro Prieto limestone. The Buelna formation is adjacent to the Cerro Prieto on the west side of the ridge. Proveedora quartzite occupies the slopes next to the Buelna formation. The westernmost ridge and knob are formed of the Puerto Blanco formation.

The valley between the two longest ridges is occupied by the Arrojos formation. The small high ridge just under *Albertella* is visible on the west side of the saddle. The easternmost ridge is Tren dolomite. Horizontal scale, 1.67 inches = 1 mile; vertical scale, 1.63 inches = 1 mile.

Photograph courtesy Bureau of Public Relations, War Department.

Plate 3

Fig. 1.—Difuntos Hills. The small hill on the right side of the picture is composed of Buelna and Cerro Prieto limestones. The larger hills on the left consist of Arrojos limestone in the lower part and Tren dolomite in the upper part.

Fig. 2.—North end of Arrojos Hills. View of the north end of the Arrojos Hills looking north along the strike of the Arrojos beds. The low hill on the left is Cerro Prieto limestone, massive and not showing bedding; the Arrojos formation occupies the middle ground of the picture. The hill on the right is Tren dolomite.

Fig. 3.—Pleosponge reef (locality 801q). Massive limestone composed of pleosponge debris, wavy-bedded pink limestone, and oolitic limestone. Located about 0.7 mile northwest of the west end of Proveedora Hills.

Plate 4

Fig. 1.—Puerto Blanco formation. Heavy ledges of limestone in the Puerto Blanco formation, west end of Proveedora Hills, 7 miles west of Caborca (locality 801b, c).

Fig. 2.—Prieto Hill (locality 809). At the left base of Prieto Hill is a low hill formed of the Proveedora sandstone. Approximately the lower half of the large hill is composed of the Buelna formation. The top of the hill is capped by a thick ledge of the Cerro Prieto limestone.

Fig. 3.—Cañedo Hill (locality 812). In the middle background the stratified but much-altered layers of Cañedo Hill are visible. To the south stretch the volcanic hills formed of the intrusive materials that altered the Cambrian sediments. The low hill on the left side of the picture is composed of Pre-Cambrian quartzite and limestone.

Fig. 4.—Proveedora Hills (Buelna and Cerro Prieto formations) (locality 801d, e). Proveedora quartzite ridges and slates on left and center. The depression in the right corner is the contact of the Buelna and Proveedora formations. The slope above the depression is Buelna limestone and the extreme right and crest of hill is Cerro Prieto limestone.

Plate 5

Fig. 1.—Lista Blanca (locality 811). View looking south from south side of Caborca road. The low hill with soft contours on the left is composed of Cretaceous (?) conglomerate. The central high part is mostly of dolomitic marble. The slates that produced the poor fossils are on the right side of the observer near the darkly shadowed hill.

Fig. 2.—West Buelna Hill (locality 807). Proveedora quartzite makes up about two-thirds of the hill; the Buelna limestone with *Onchocephalus* and olenellid trilobites appears under the two knobs. The peaks are composed of Cerro Prieto algae-bearing massive limestone.

Fig. 3.—*Girvanella* on slope of Prieto Hill. Surface of the Cerro Prieto limestone on Prieto Hill, 1½ miles southwest of Caborca, showing numerous dark- and light-colored *Girvanella.* These may be the objects that were originally referred to *Chaetetes.*

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Surface of a polished slab oriented perpendicular to the stratification showing the colonies of *Girvanella,* × 1.

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Fig. 1.—*Ethmophyllum cooperi* Okulitch, new species, × 8 29
Holotype, U.S.N.M. No. 111814a, specimen marked O-1 "A." Showing the thick complex inner wall and several parietes. The outer wall is missing.

Fig. 2.—*Ethmophyllum cooperi* Okulitch, new species, × 16 29
Holotype, U.S.N.M. No. 111814a, specimen marked O-1 "A." Showing details of inner wall and vertical canals, some at the point of opening into the central cavity.

Fig. 3.—*Ethmophyllum americanum* Okulitch, new species, × 8 30
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Fig. 4.—*Ethmophyllum americanum* Okulitch, new species, × 56 30
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Fig. 5.—*Ajacicyathus nevadensis* (Okulitch), × 8 28
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Fig. 6.—*Ajacicyathus nevadensis* (Okulitch), × 16 28
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Fig. 1.—*Syringocnema* species, × 0.8 33
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Fig. 2.—*Syringocnema* species, × 5 33
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Fig. 4.—*Ethmophyllum whitneyi* Meek, × 7 28
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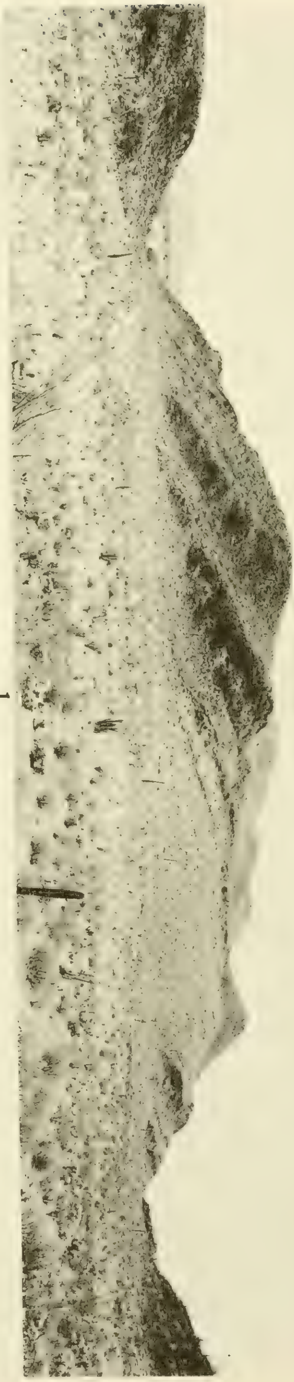

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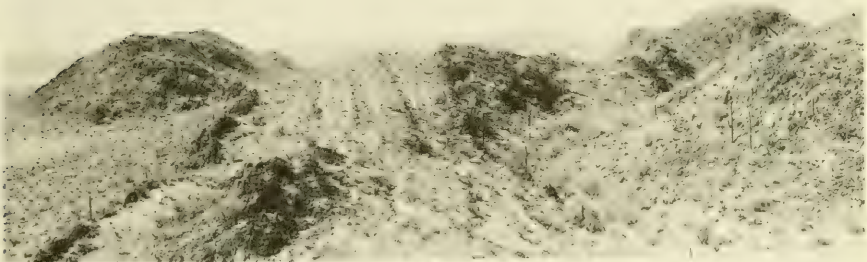

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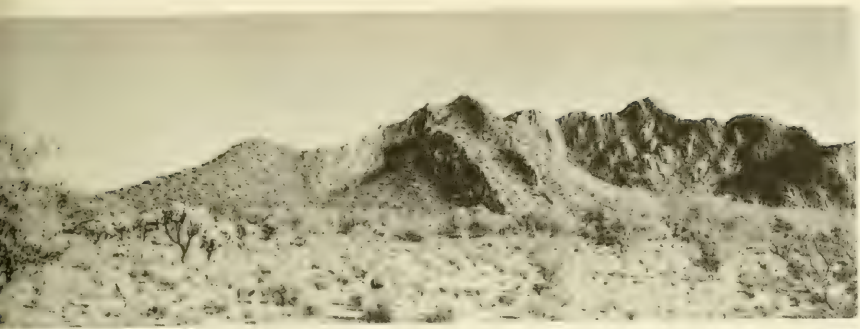

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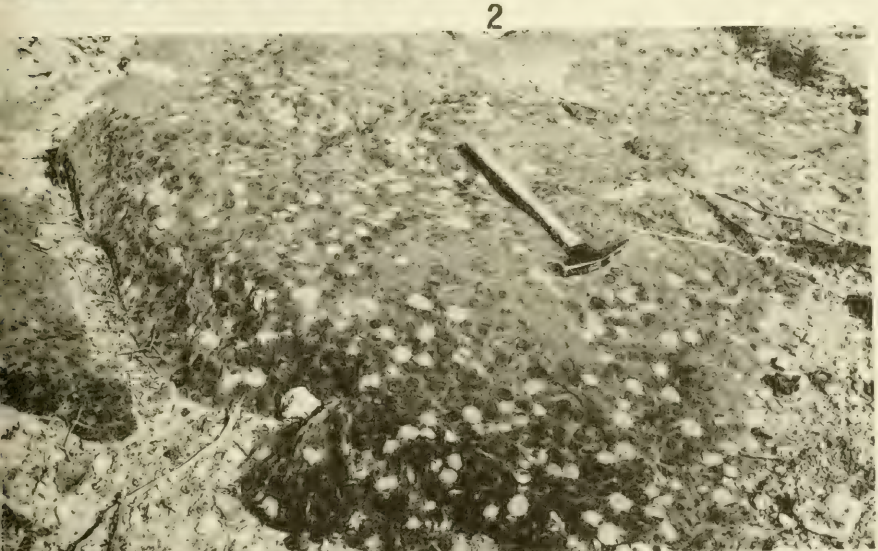

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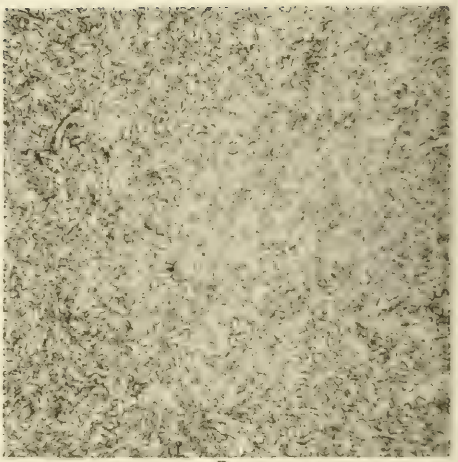

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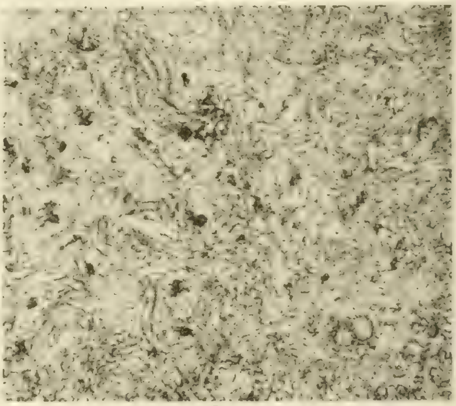

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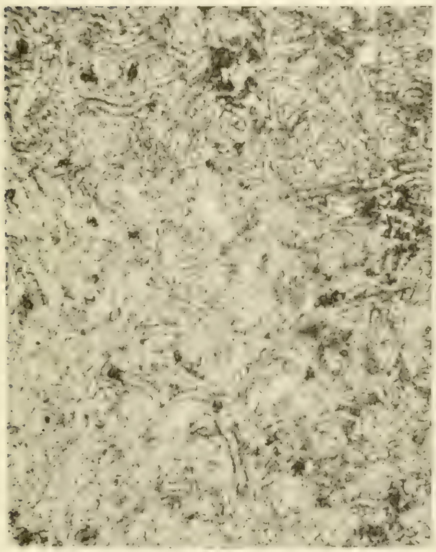

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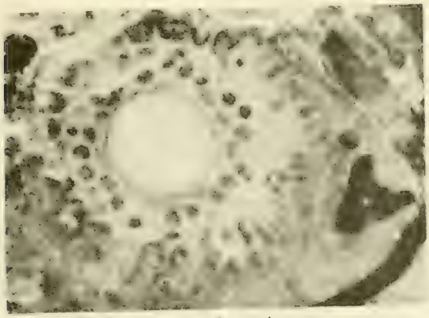

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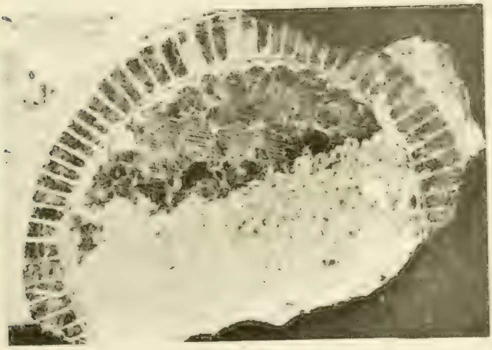

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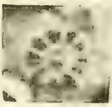

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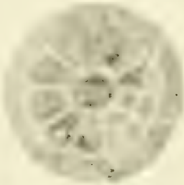

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PLEOSPONGIA

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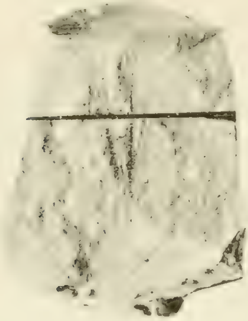

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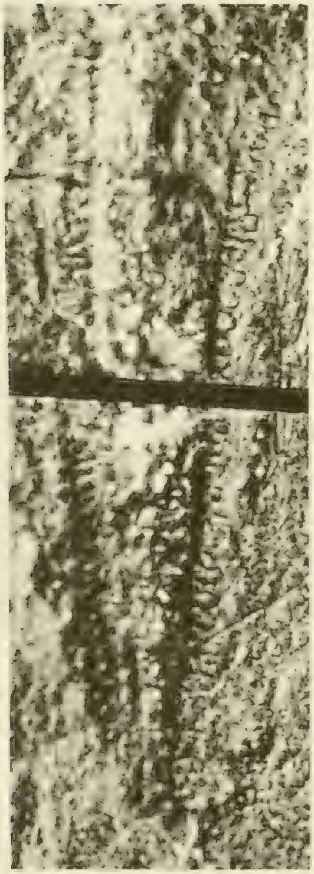

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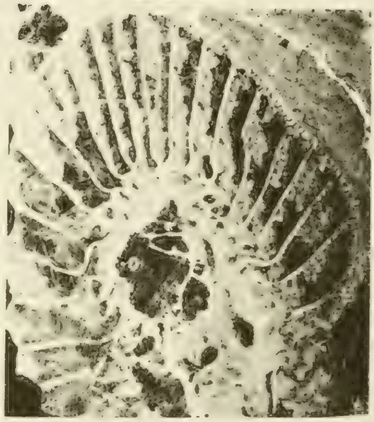

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PLEOSPONGIA

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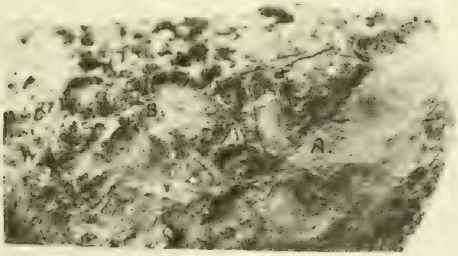

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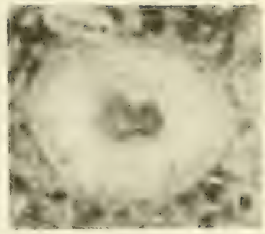

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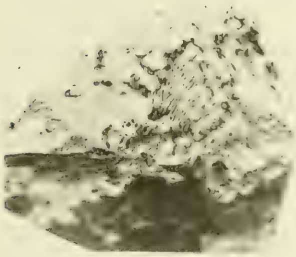

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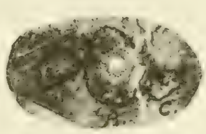

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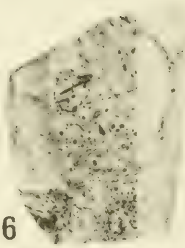

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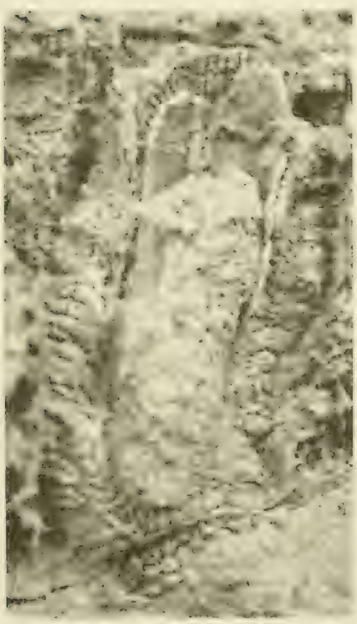

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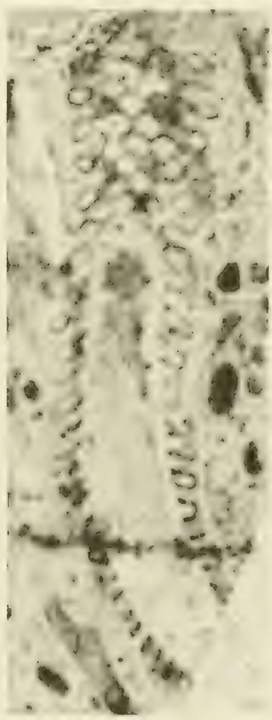

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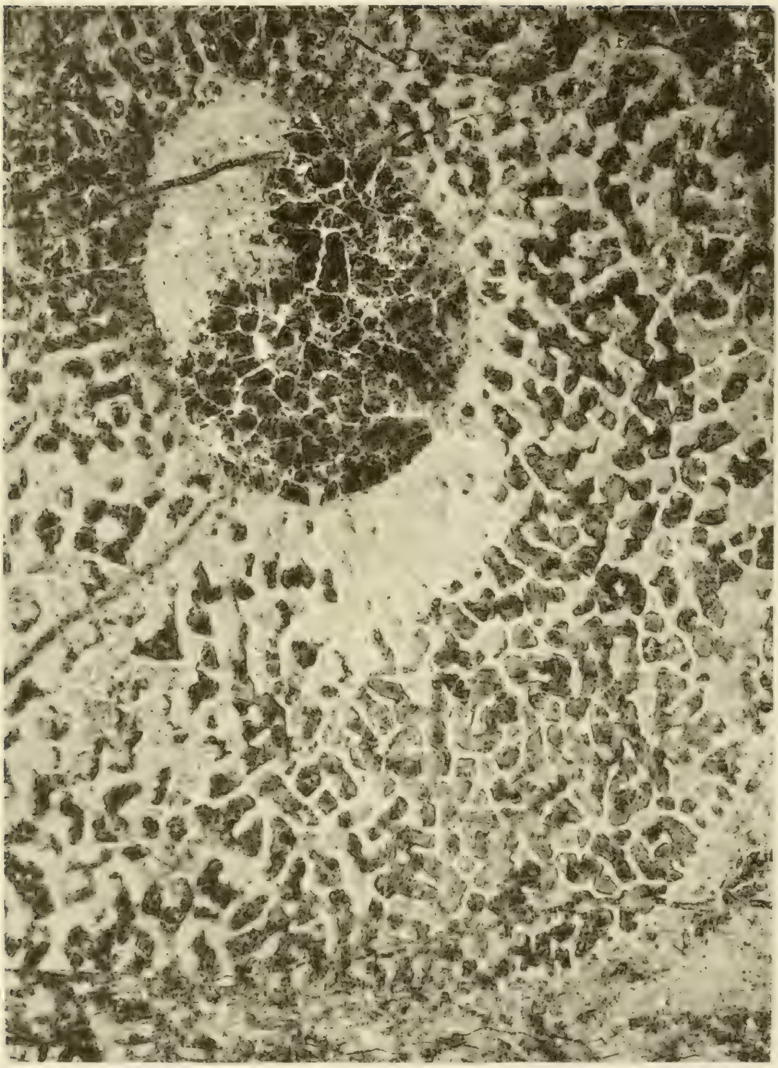

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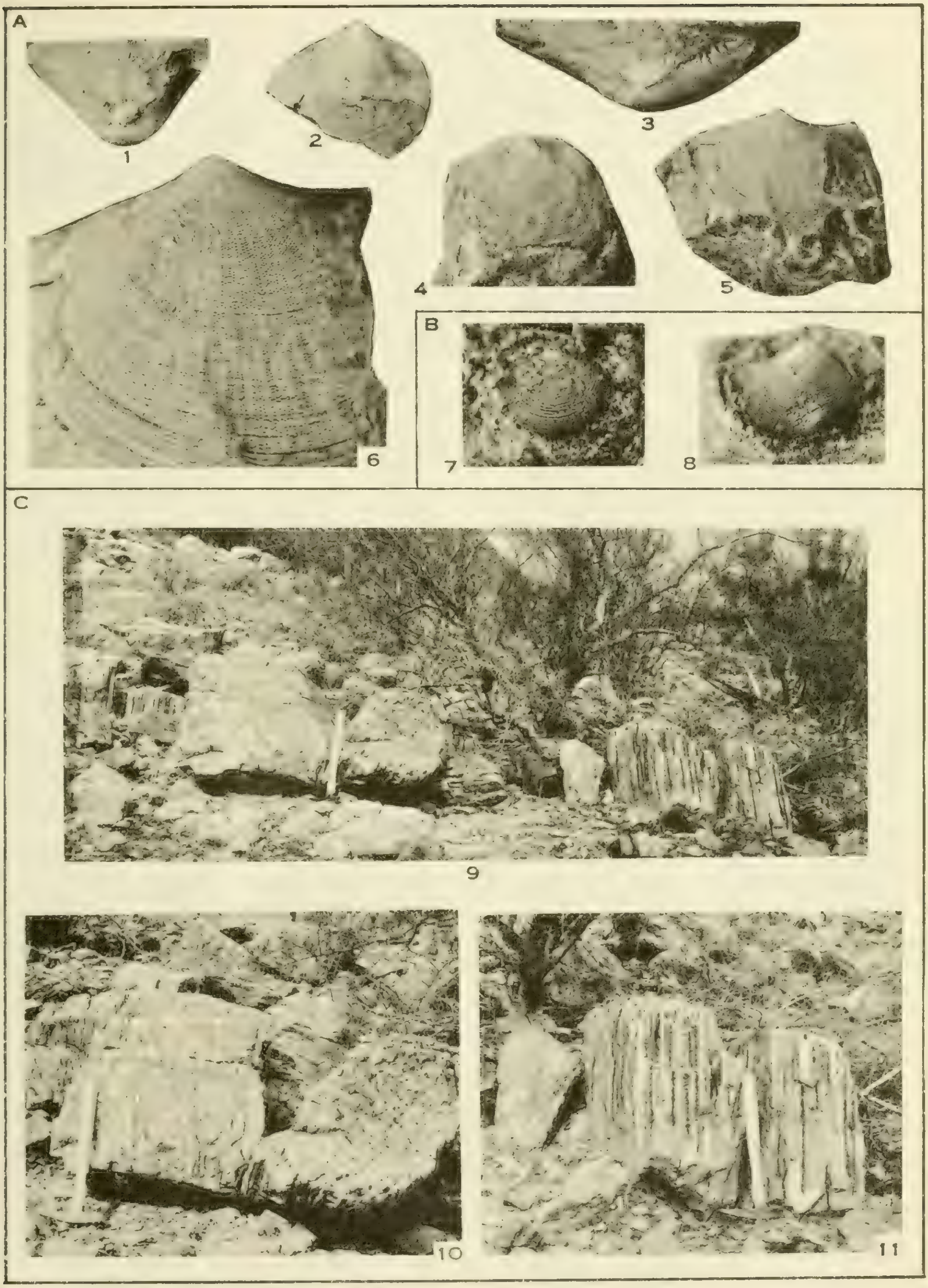

BRACHIOPODA

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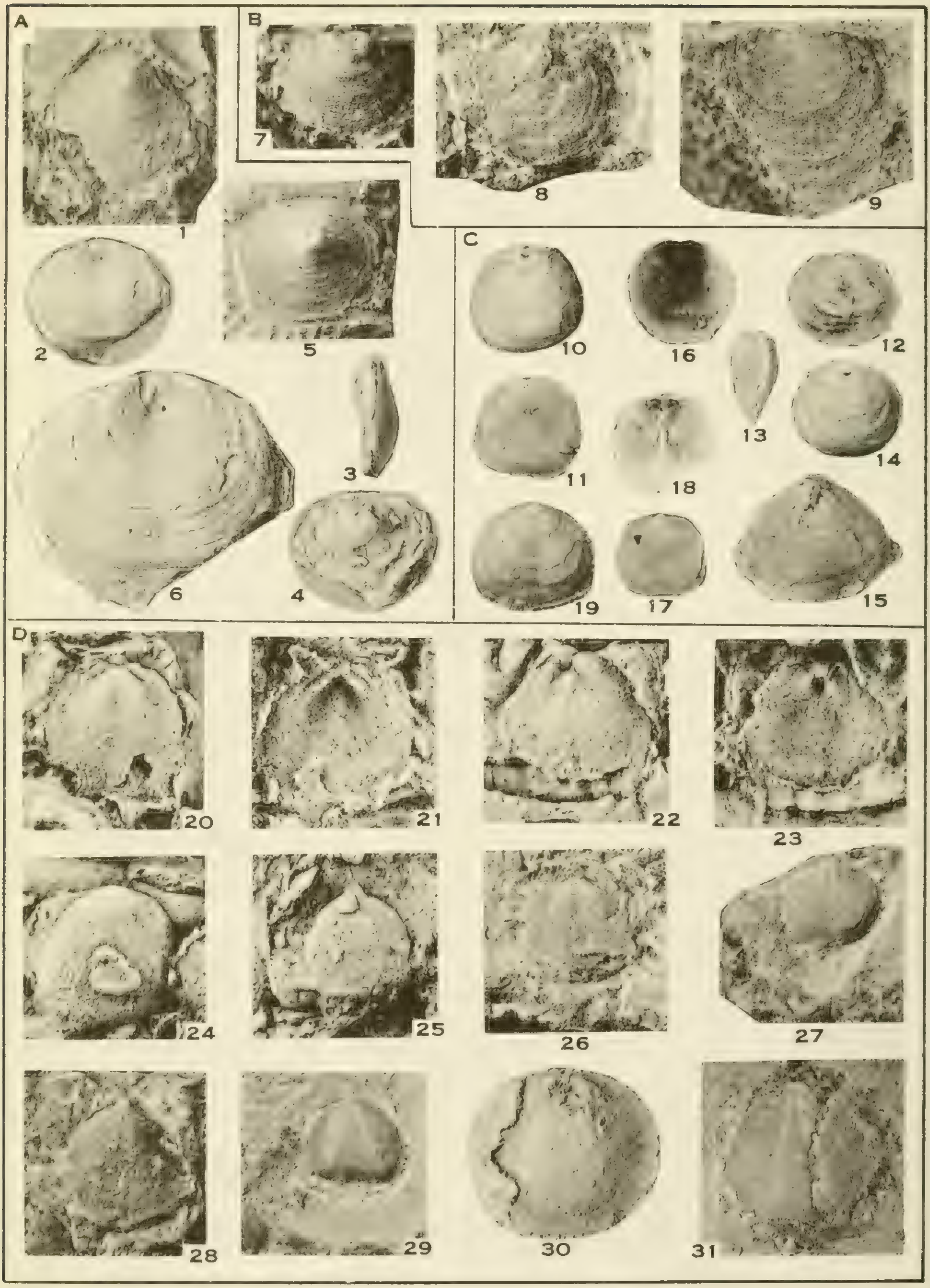

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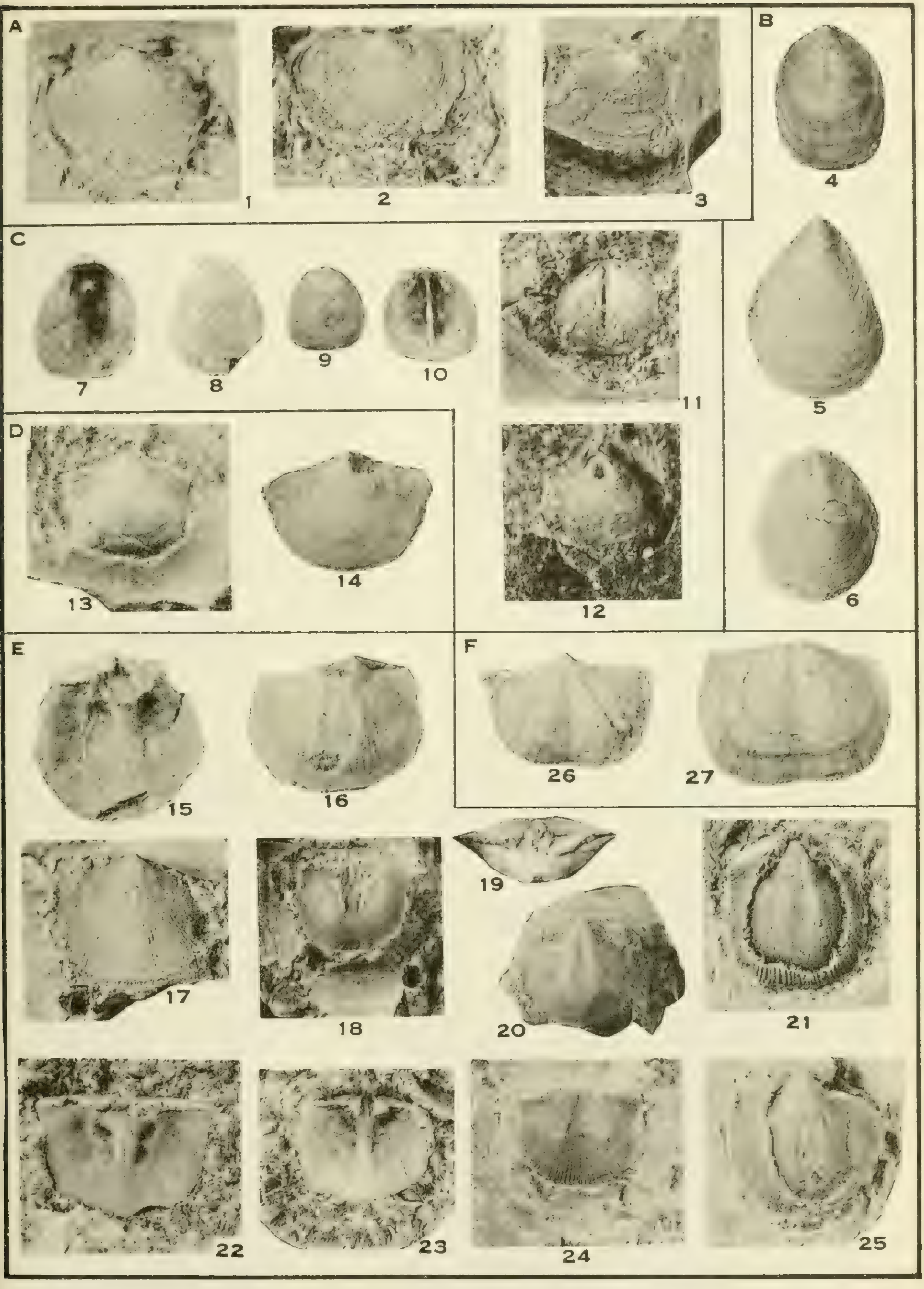

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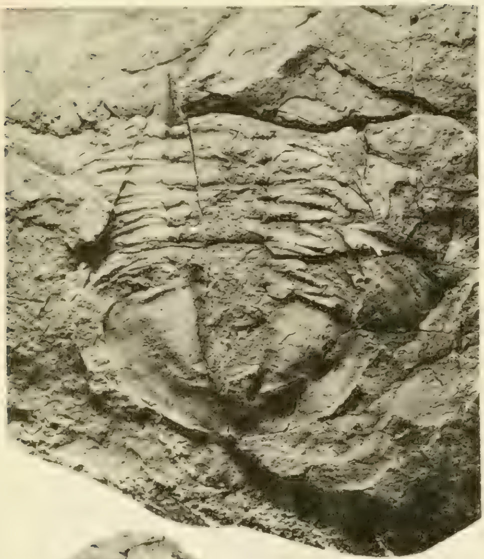

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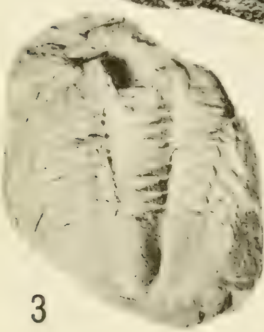

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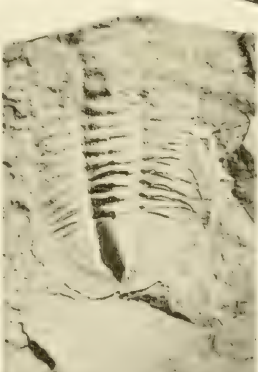

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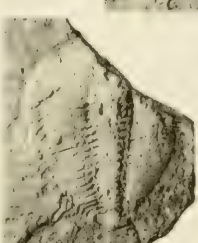

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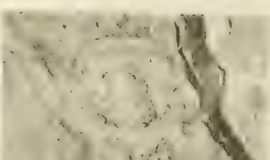

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ORIGINAL COLLECTION OF CAMBRIAN TRILOBITES FROM SONORA

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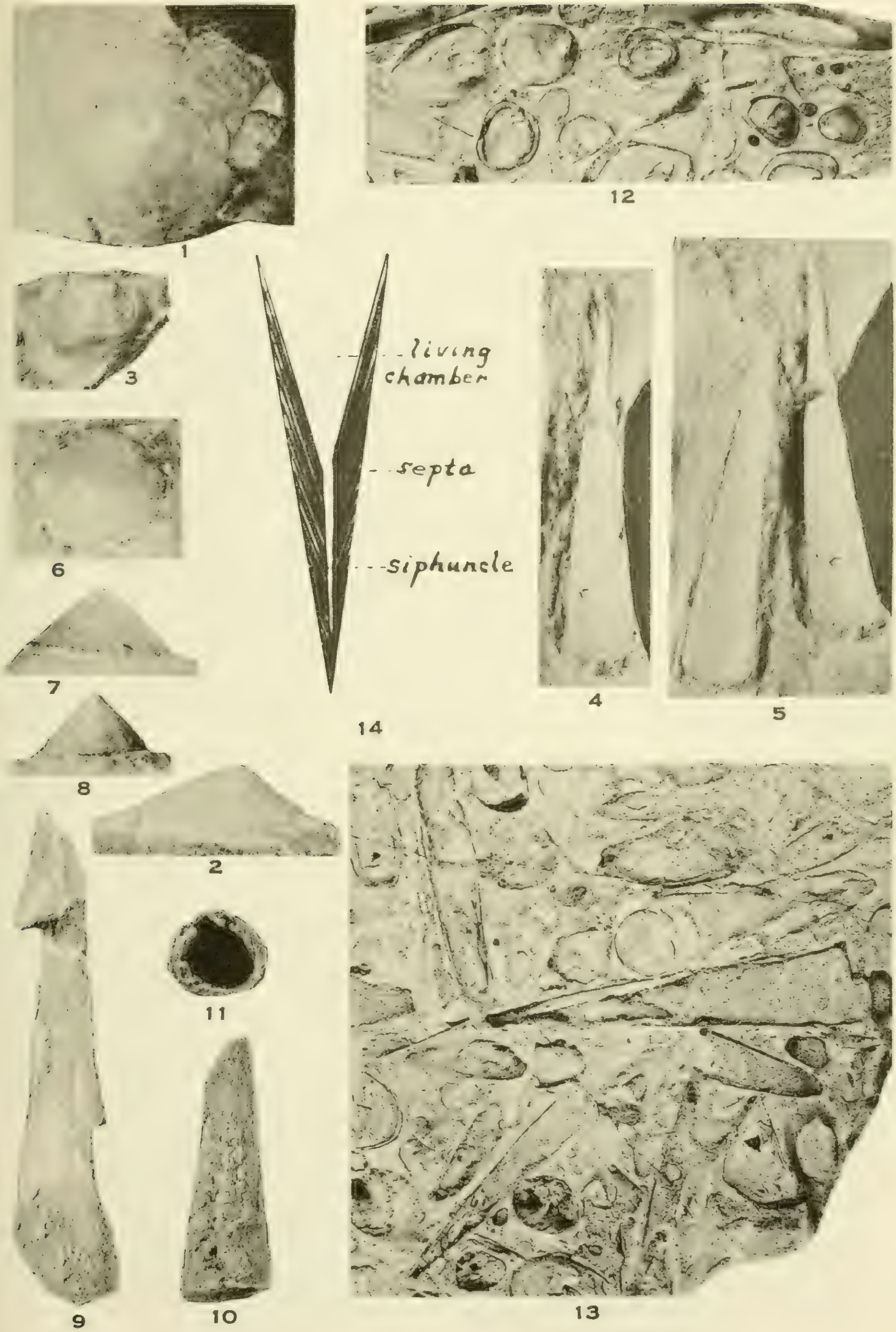

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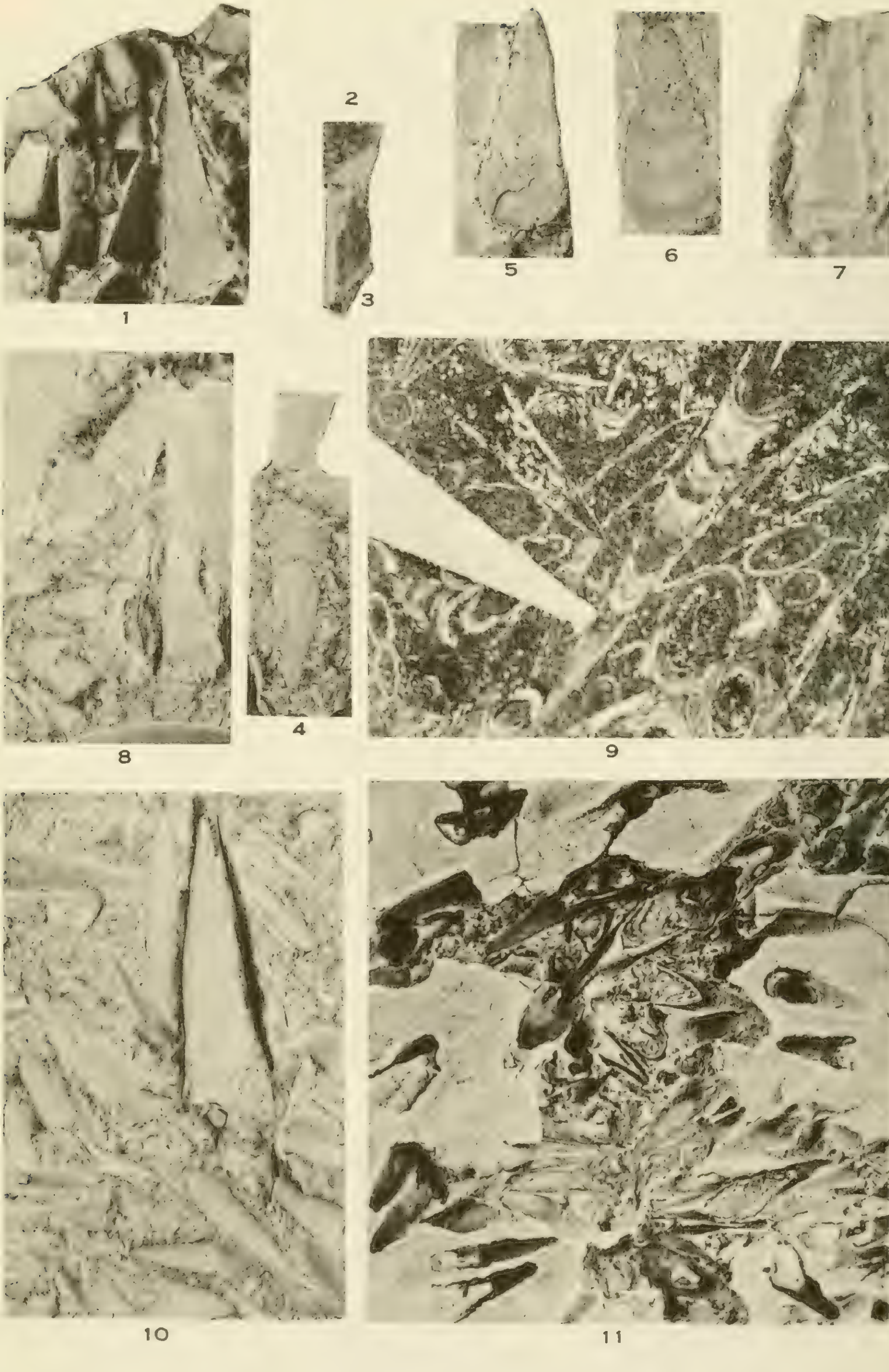

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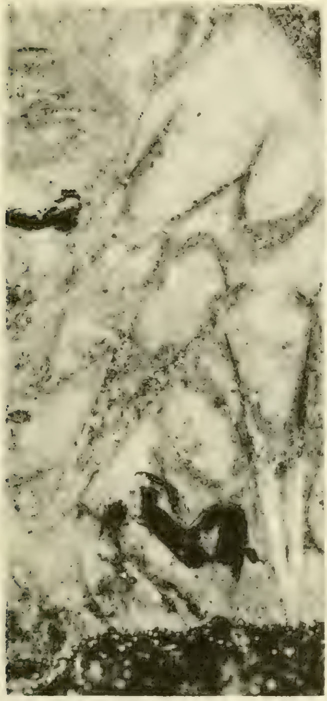

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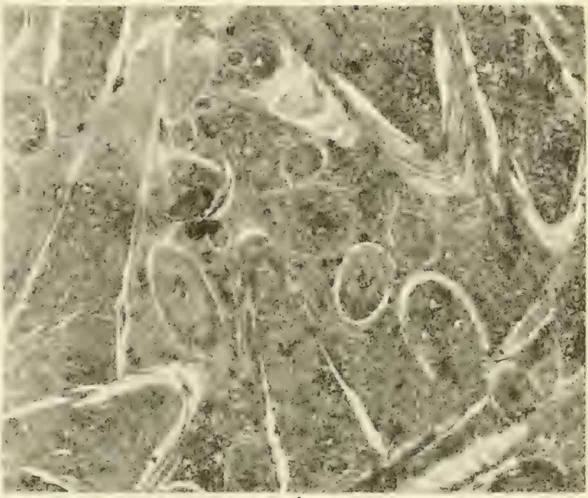

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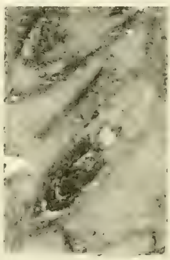

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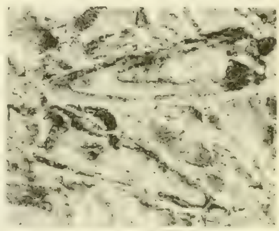

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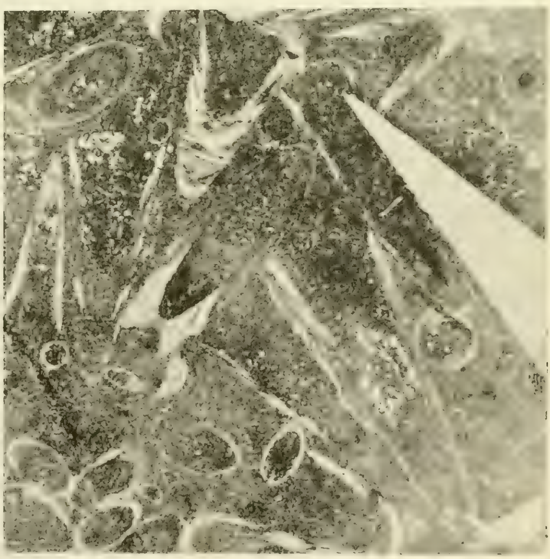

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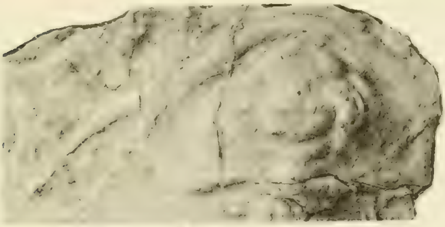
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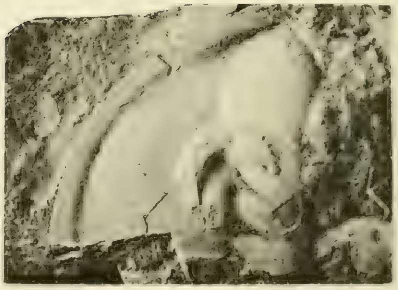
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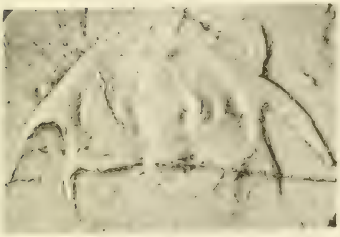
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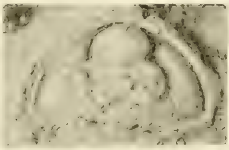
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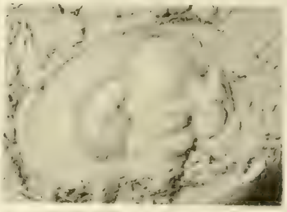
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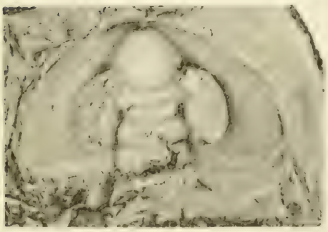
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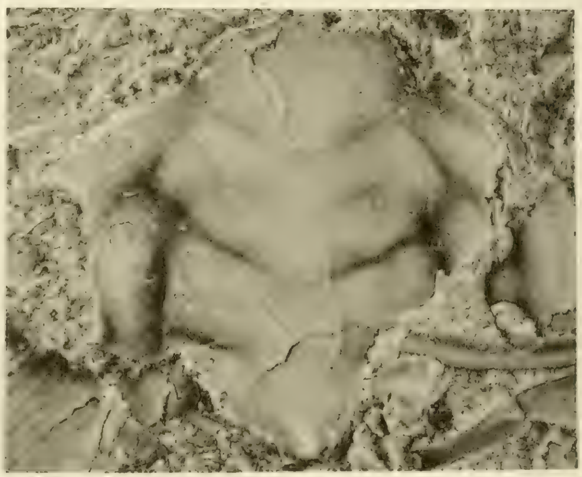
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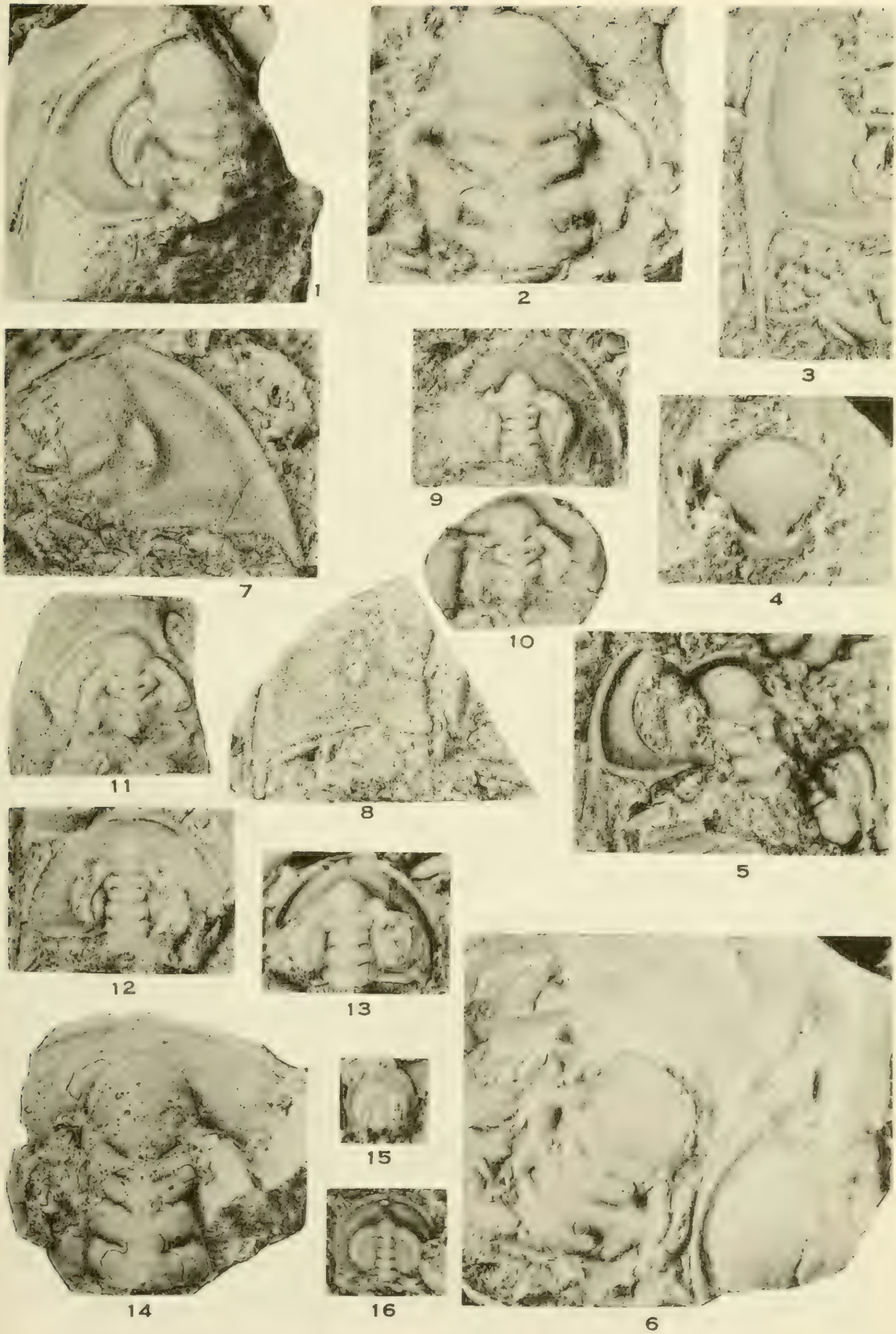

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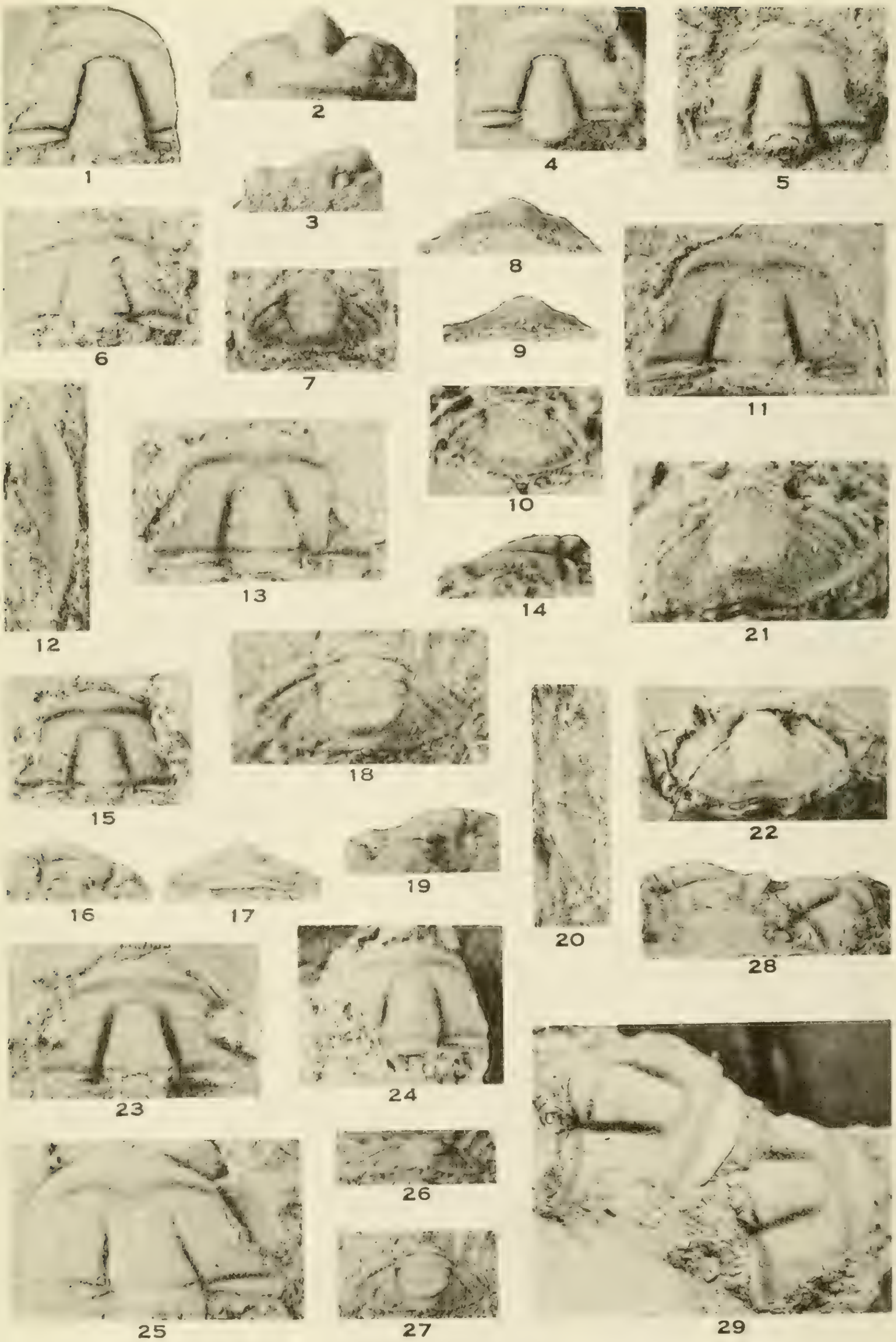

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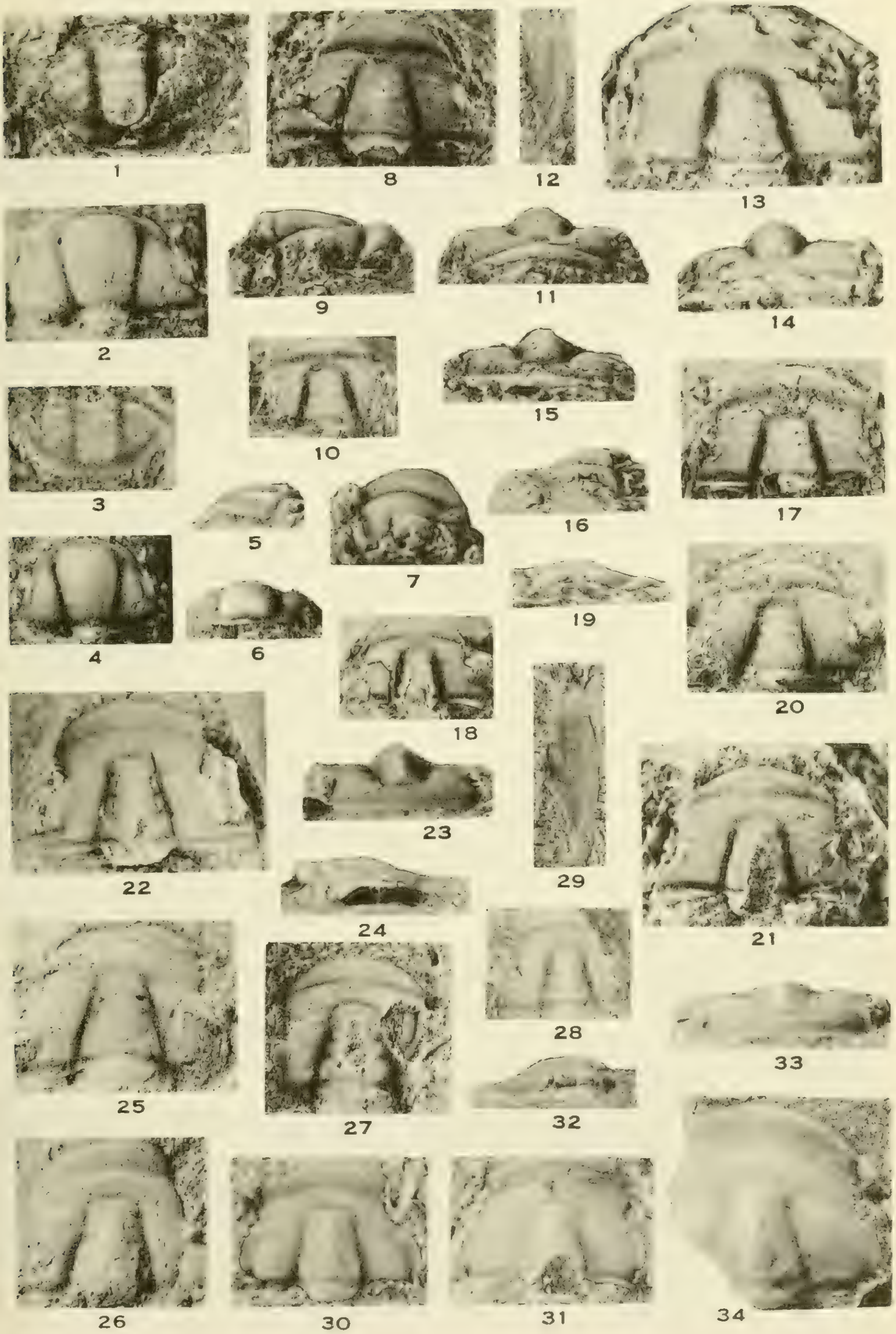

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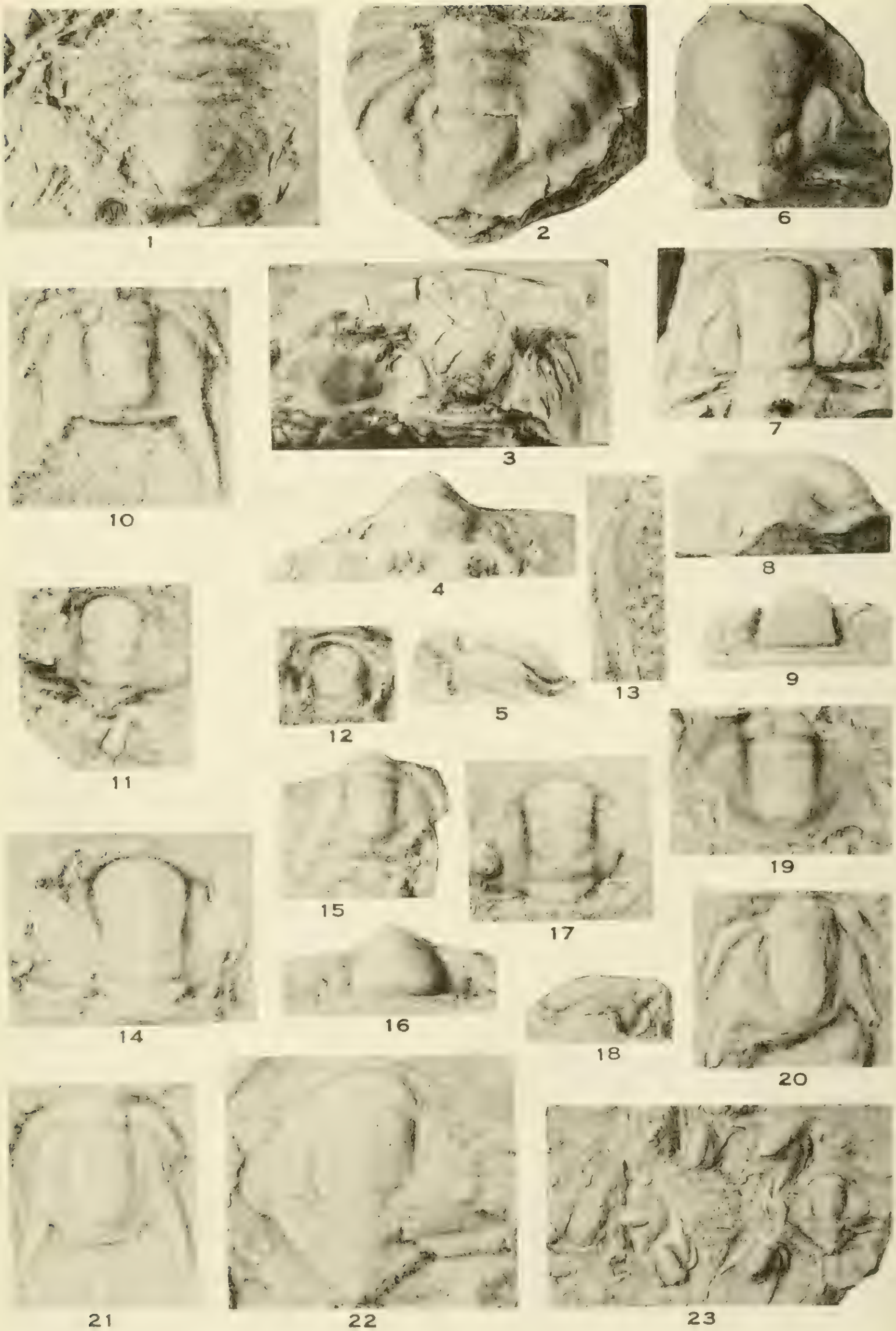

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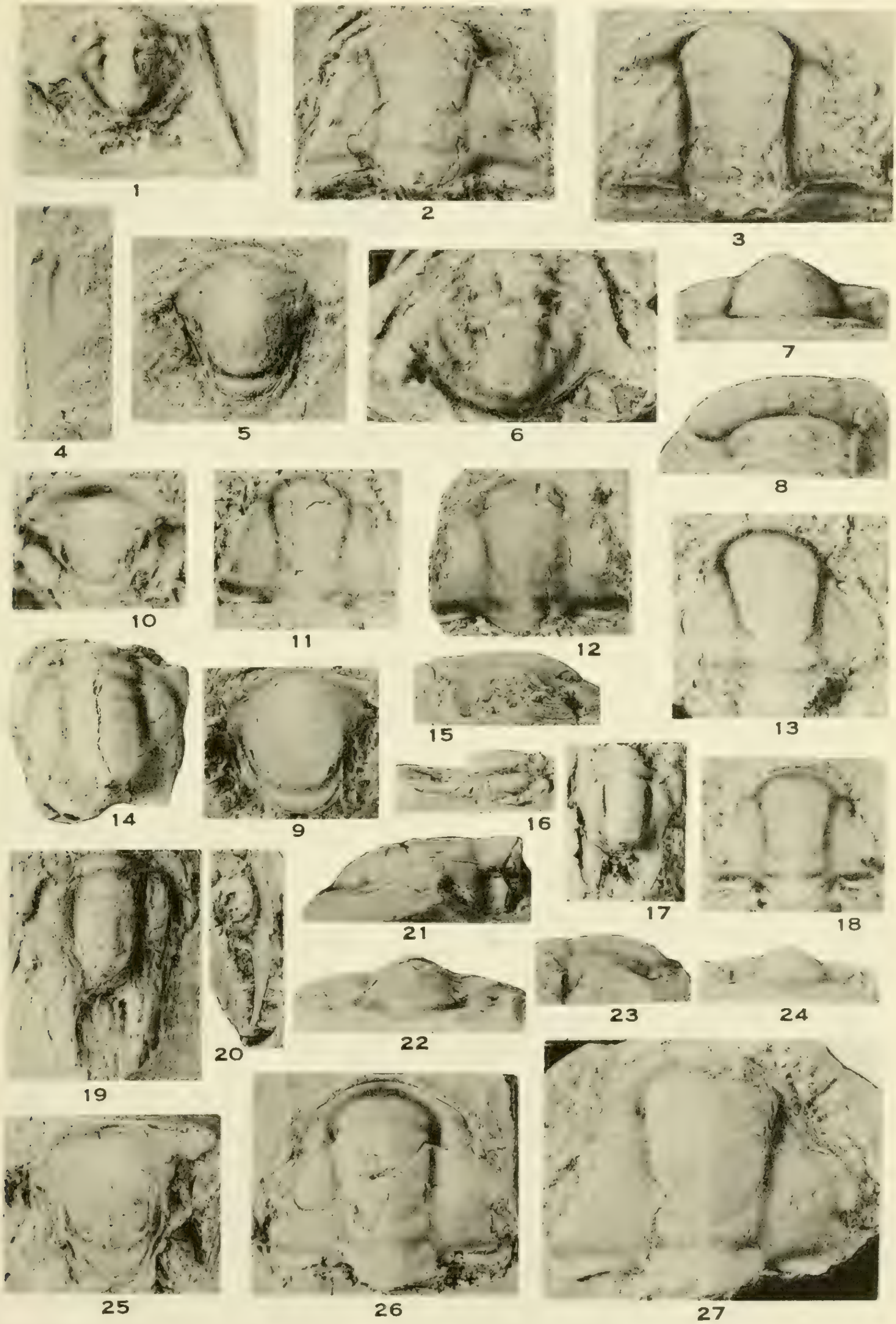

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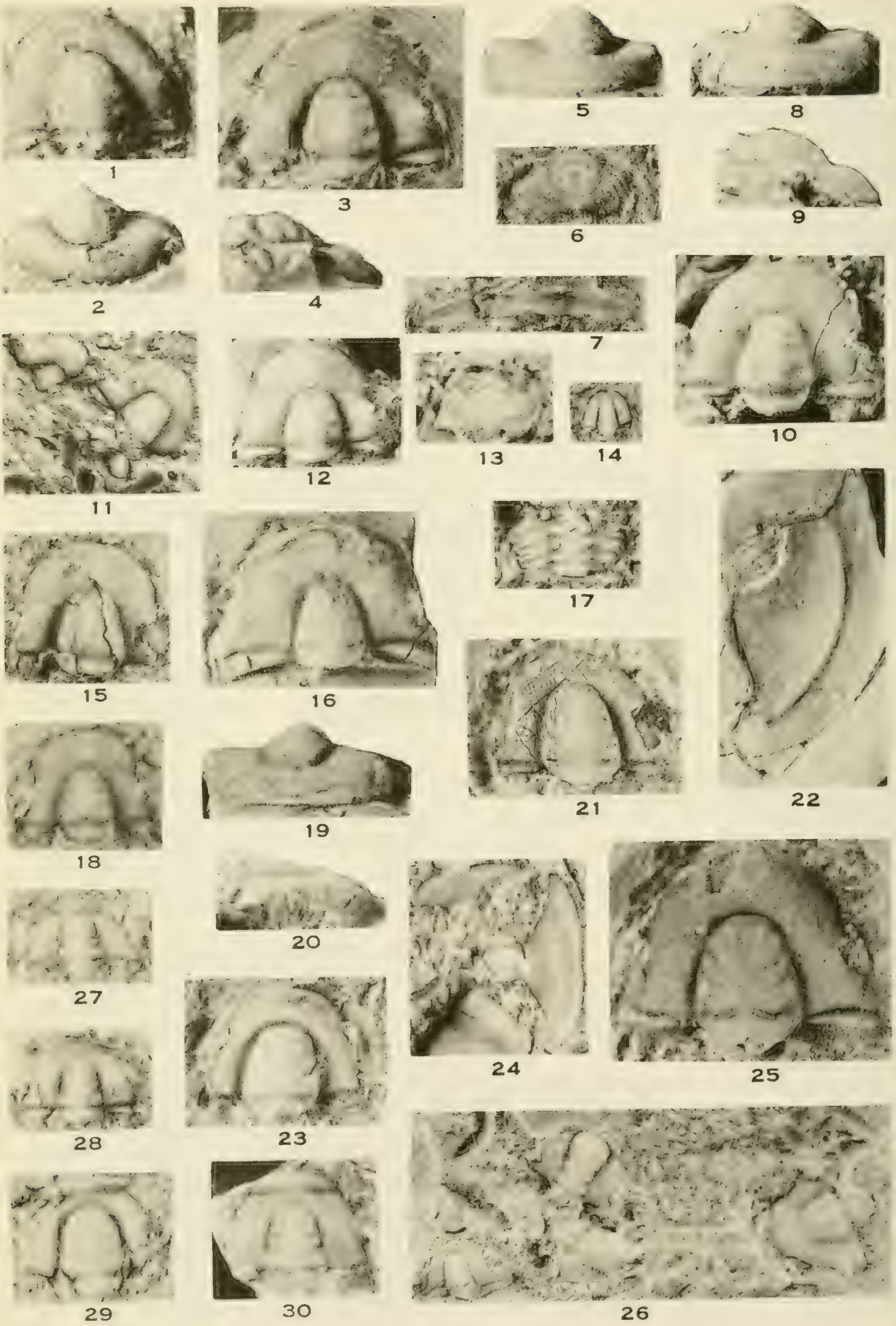

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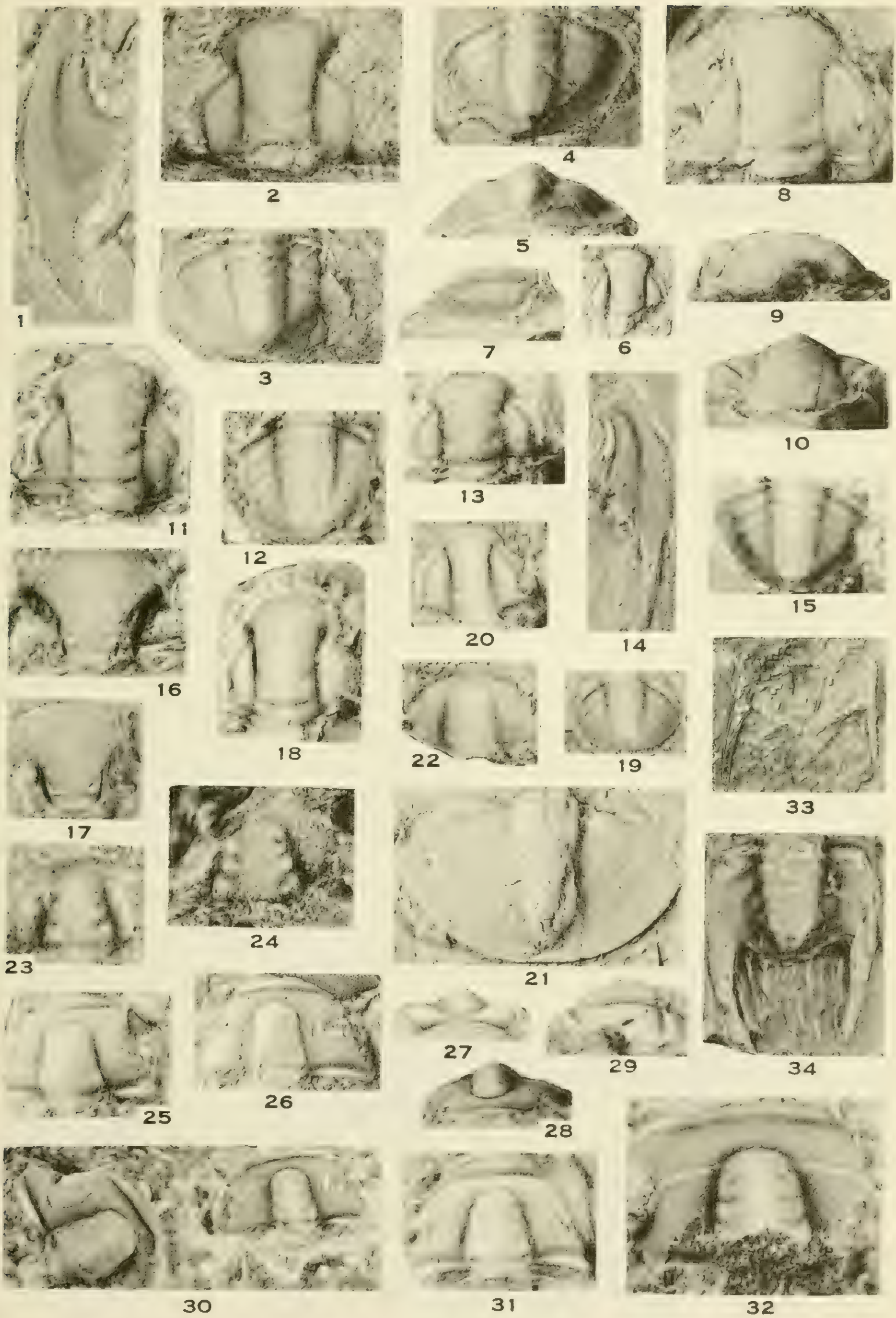

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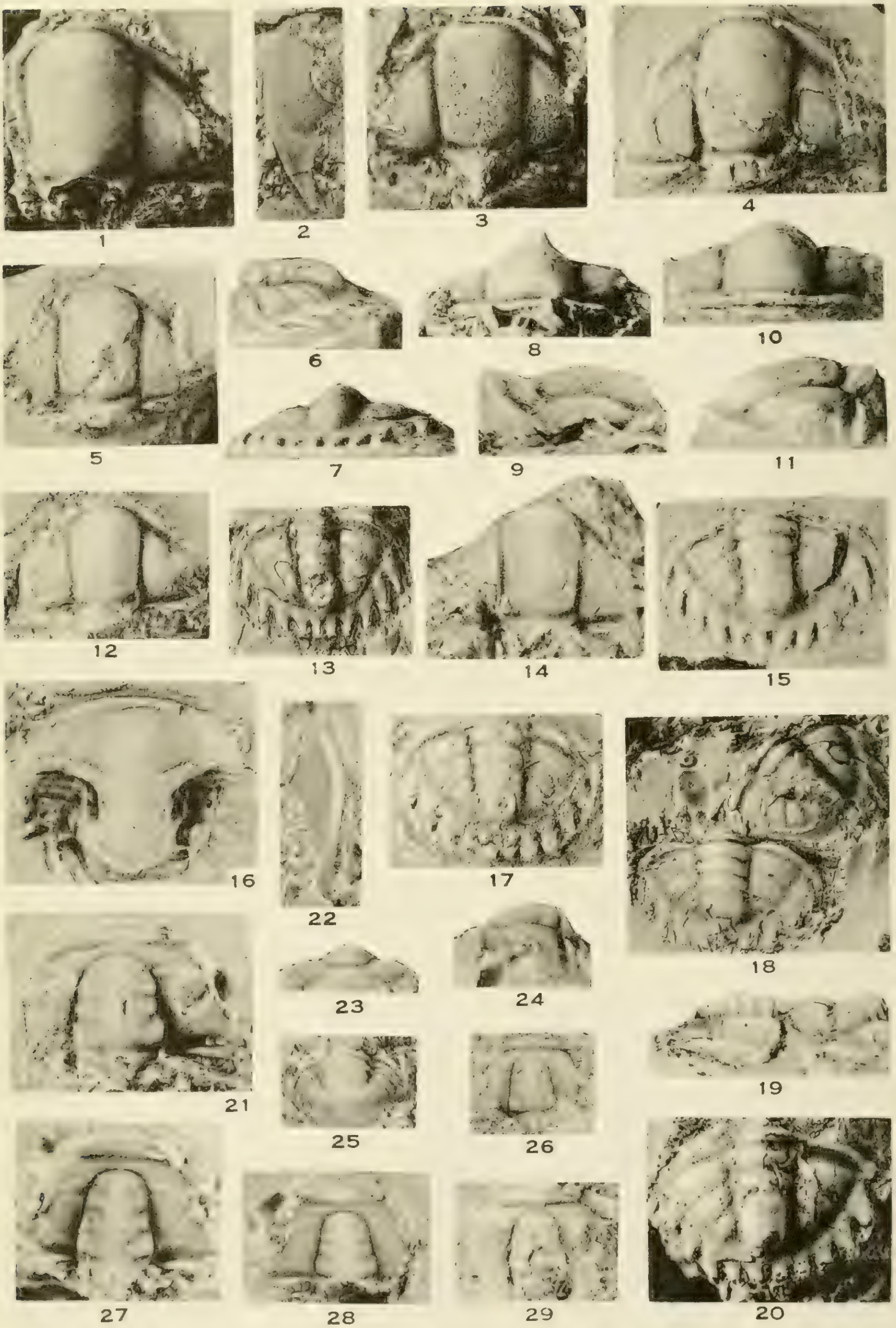

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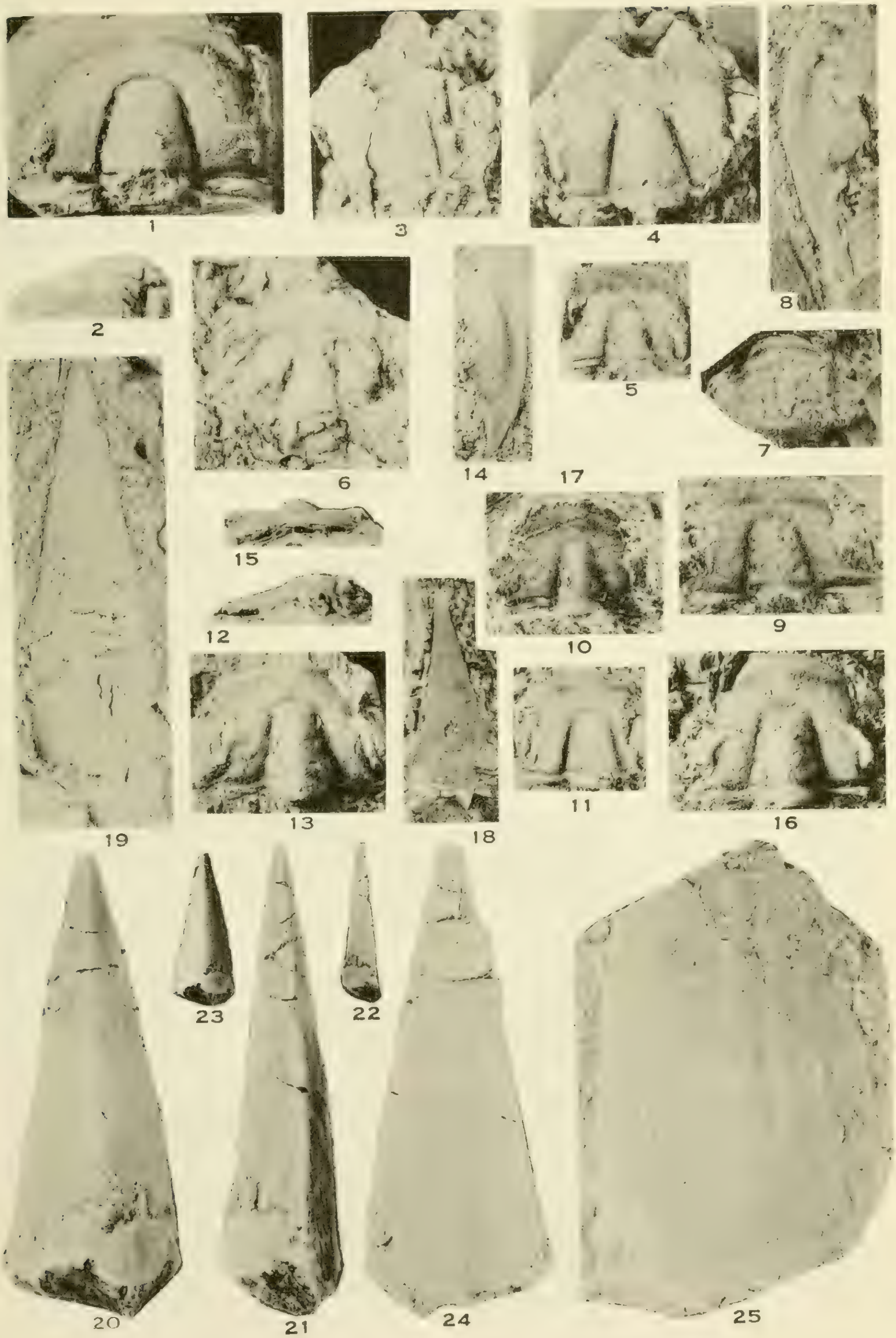

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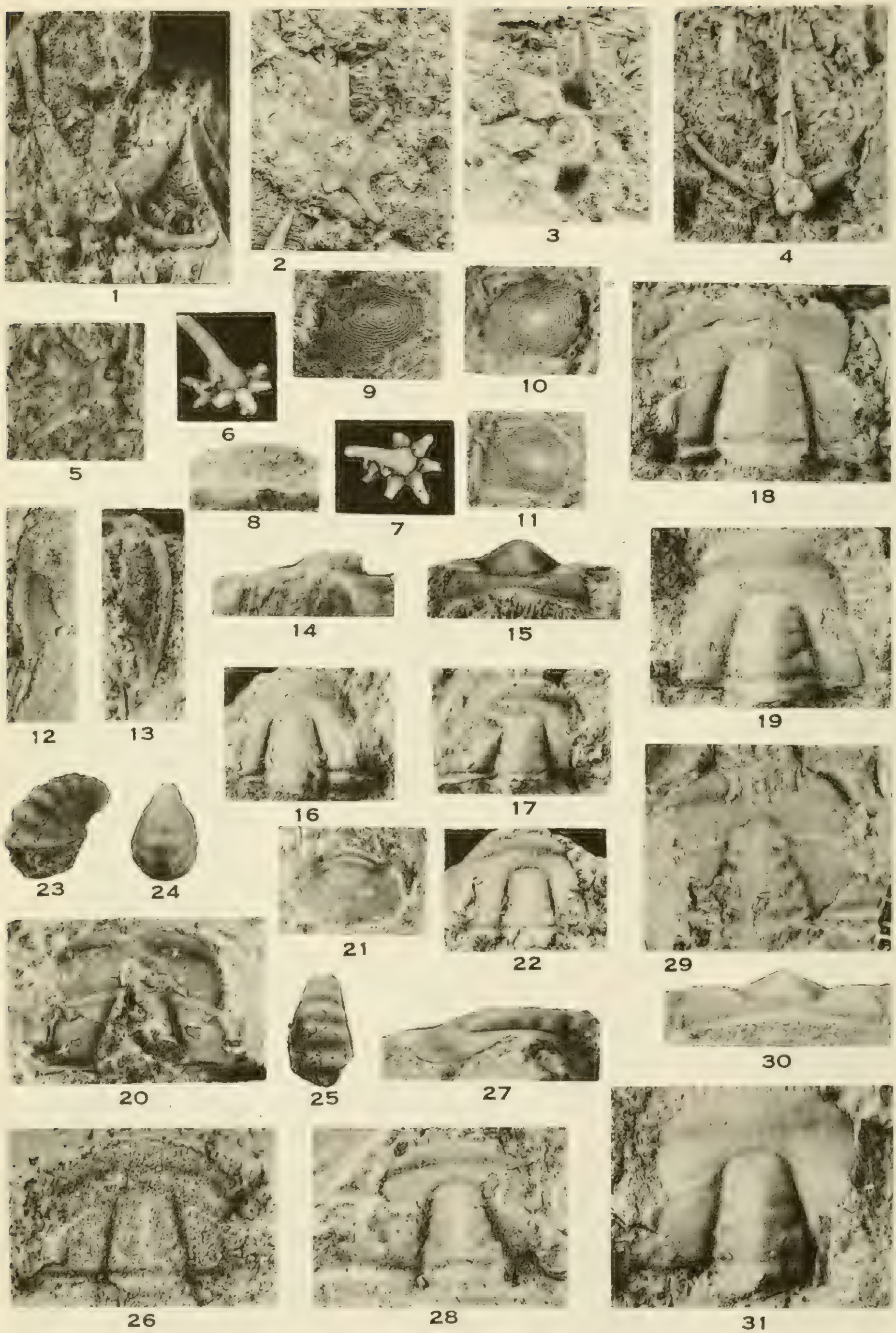

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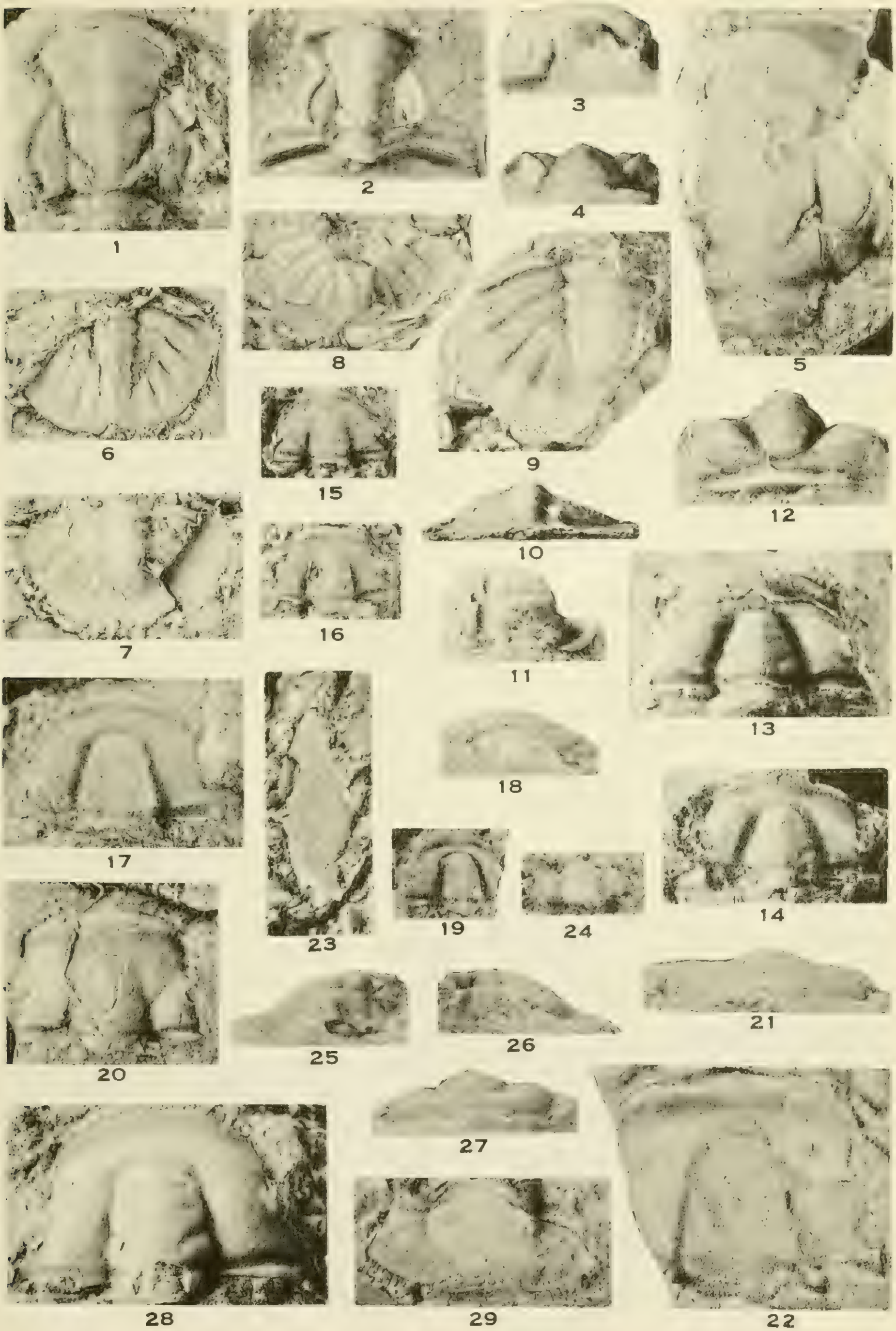

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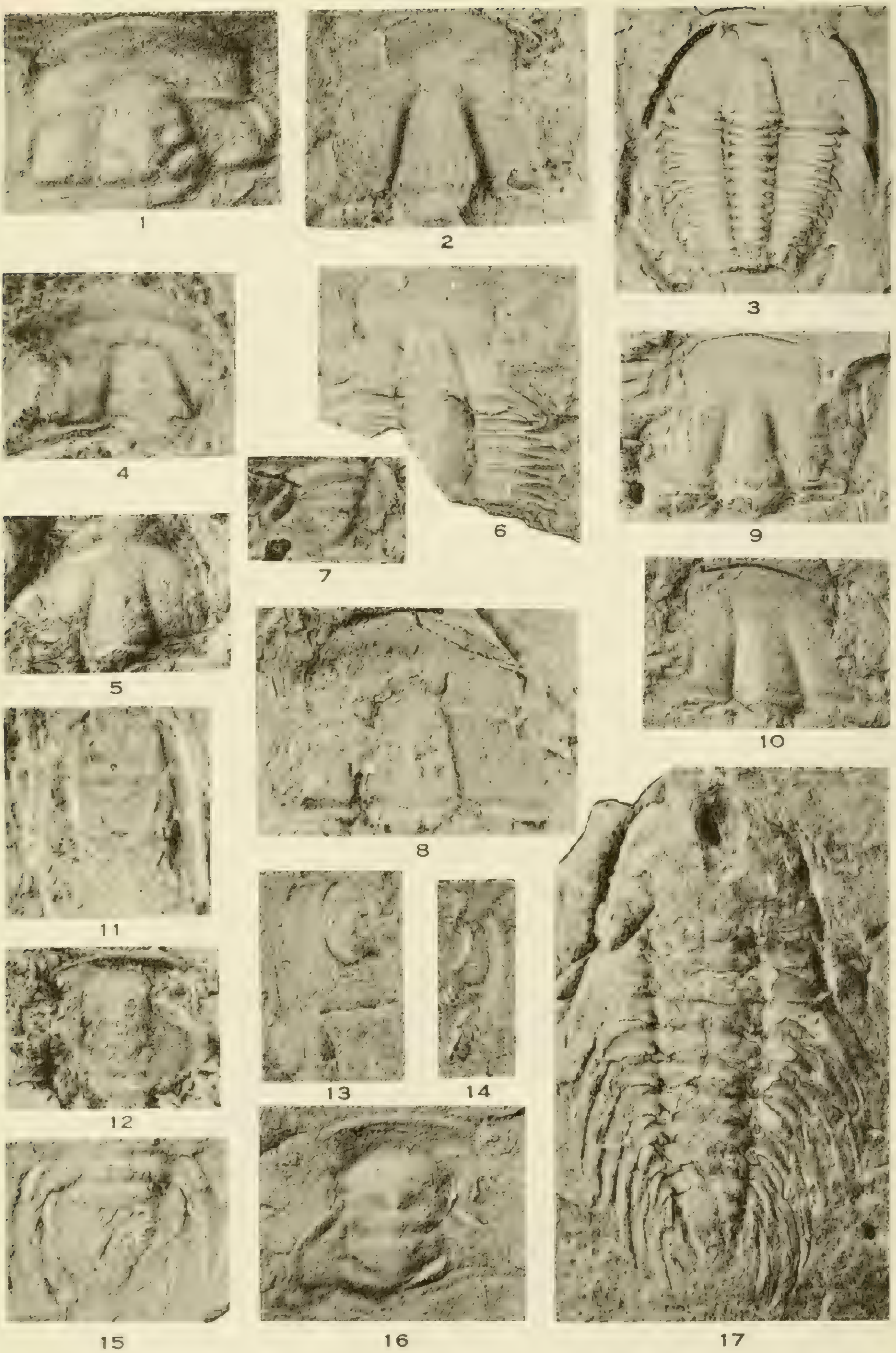

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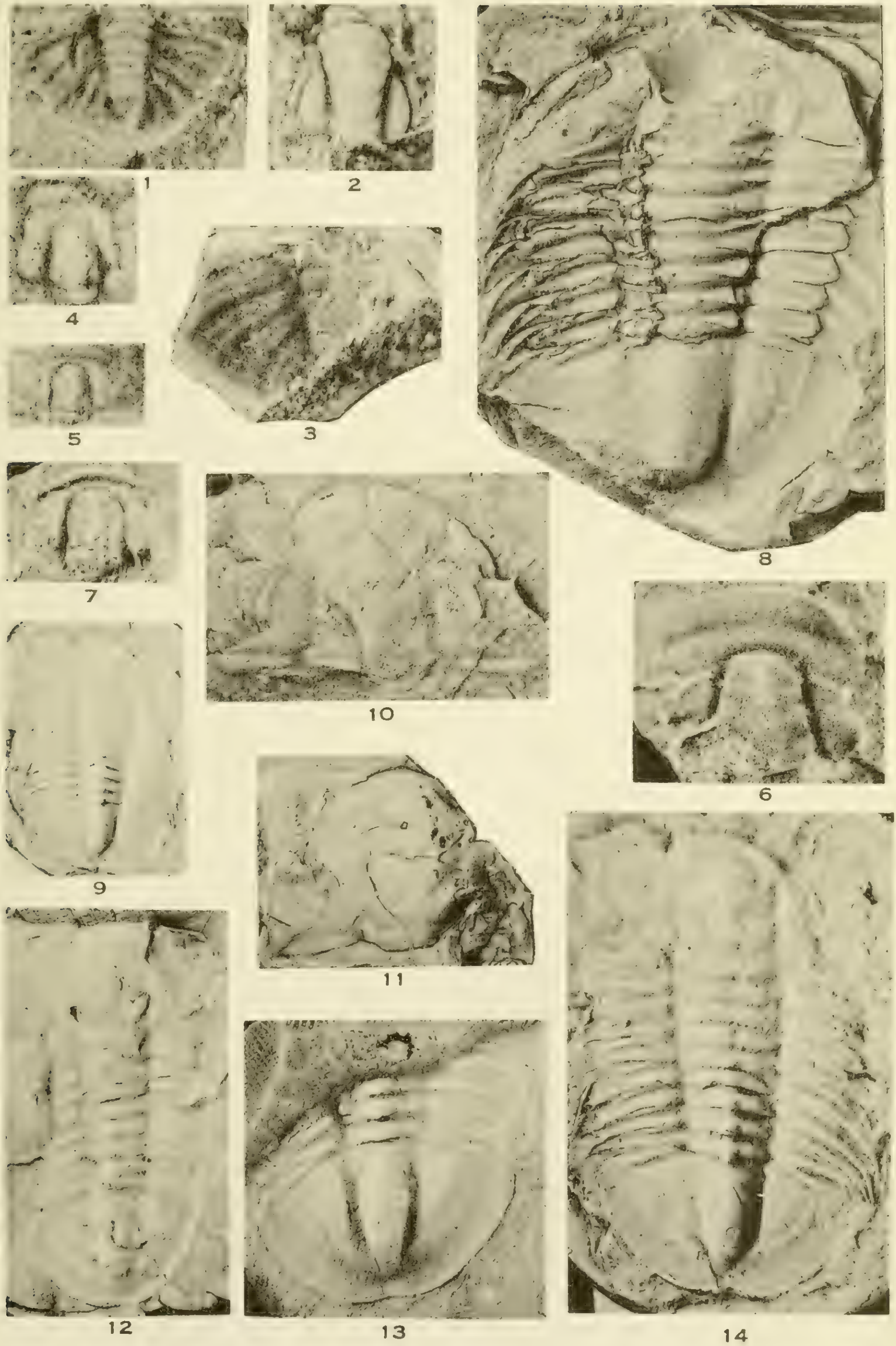

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SMITHSONIAN MISCELLANEOUS COLLECTIONS
VOLUME 119, NUMBER 2

Charles D. and Mary Vaux Walcott Research Fund

PERMIAN FAUNA AT EL ANTIMONIO, WESTERN SONORA, MEXICO

(With 25 Plates)

BY

G. ARTHUR COOPER
CARL O. DUNBAR
HELEN DUNCAN
ARTHUR K. MILLER
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(Publication 4108)

CITY OF WASHINGTON
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PERMIAN FAUNA AT EL ANTIMONIO, WESTERN SONORA, MEXICO

STRATIGRAPHY AND FAUNAL ZONES

By G. ARTHUR COOPER
United States National Museum

(Plates 1 and 25)

INTRODUCTION

About 30 miles west of Caborca, at the mining camp of El Antimonio, a sequence of Permian rocks was discovered by W. T. Keller (1928). This discovery was later confirmed by A. Stoyanow (1942), of the University of Arizona. Originally these rocks were not recognized as of Permian age, but our collections made during the seasons of 1943 and 1944 definitely establish the sequence as Middle Permian (Word).

The strata near El Antimonio were studied by Keller during an examination of the area for its oil possibilities. He noted the complexity of the structure but did not present a stratigraphic column. He recognized there a Caborca Division, one of the three parts into which he divided the rocks of northwestern Sonora. The Caborca Division consisted of the Monos beds at the top and the Gamusa beds below. The name "Monos beds" was applied to the upper part of the Caborca Division after the Monos Hills in which they are exposed. These hills are located a short distance east and northeast of El Antimonio. Keller recognized the fossils collected as belonging to Permo-Carboniferous types and related the fauna to that of the Pennsylvanian rocks around Bisbee, Ariz.

The Gamusa beds in the lower sequence of the Caborca Division occur some 9 miles south of Pitiquito and are now known to be of pre-Cambrian age. It is not important therefore to discuss the rocks of this series any further.

In 1928 Keller summarized his Mexican studies in an article published in Switzerland and concluded that the whole Monos series belongs in the Pennsylvanian Period.

Stoyanow (1942) assigned a Permian age to some fossils from the Monos formation referred to him by I. G. Gómez and L. Torres. Conspicuous in this collection was the Permian productid *Waagenoconcha montpelierensis.* Early in 1945 A. K. Miller described and figured a goniatite collected by Cooper and Arellano in the upper part of the Monos formation which proved to be *Waagenoceras,* but the specimen was so poorly preserved that it could be referred only with doubt to the species *W. dieneri* Böse. This discovery of *Waagenoceras,* combined with that of *Waagenoconcha montpelierensis* by the Mexican geologists Gómez and Torres, fixes the age of the beds as Permian. The extensive fauna now known from the Monos formation permits an even closer correlation.

In 1946 Cooper and Arellano briefly described their work in northwestern Sonora and there mentioned *Parafusulina* in addition to the two other Permian types already noted. This fossil, added to the others, proves the age of the Monos formation as Middle Permian (Word).

GEOGRAPHICAL SETTING OF THE MONOS FORMATION

The Permian rocks at El Antimonio are confined to the Monos Hills which lie about 1½ miles east and northeast of the mining settlement. These hills form a crescent with its convex side facing El Antimonio. Most of the hills are low; the highest are about 400 feet above the surrounding country. The top of the section is on the outside of the arc. The rocks are faulted and intruded to such an extent that it is difficult to establish an accurate stratigraphical section. Nevertheless a sequence was pieced together from the beds exposed on the inside of the arc at the north end on the hill where a mill (molino) is located. This locality is here referred to as Mill Hill.

FAUNAL ZONES

The lower 1,000 to 1,500 feet of the sequence is poorly exposed. This part of the section is best seen in an area extending from the igneous body with elevation 156 meters (see map, fig. 2) southwestward toward the hill on which the Caracol mine is situated (295 meters elevation). The horizontal distance from this igneous body to the base of the *Anidanthus* zone is about 2,200 feet. The beds dip 35 to 40 degrees. The rocks in this interval, as revealed in patches and ex-

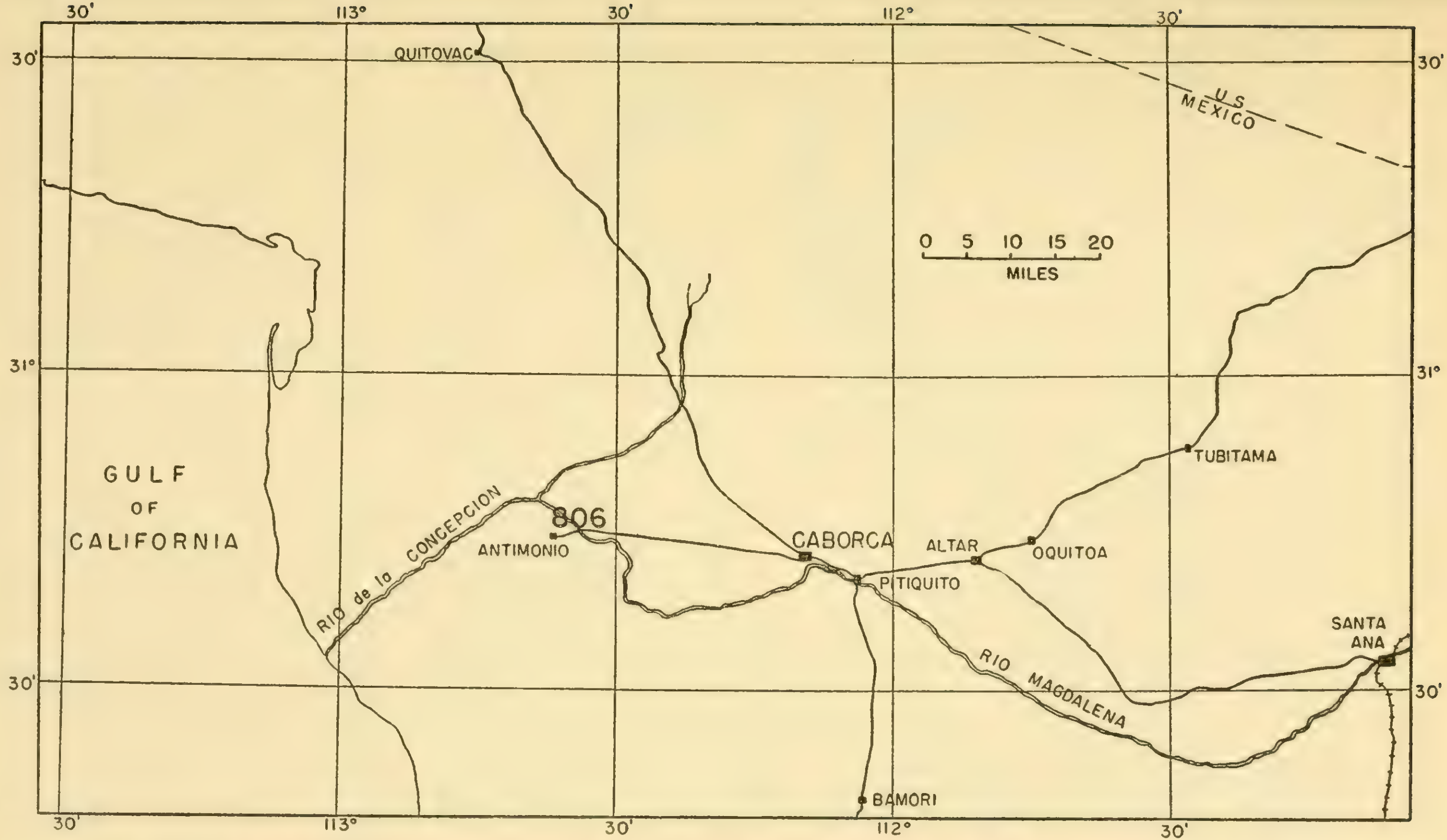


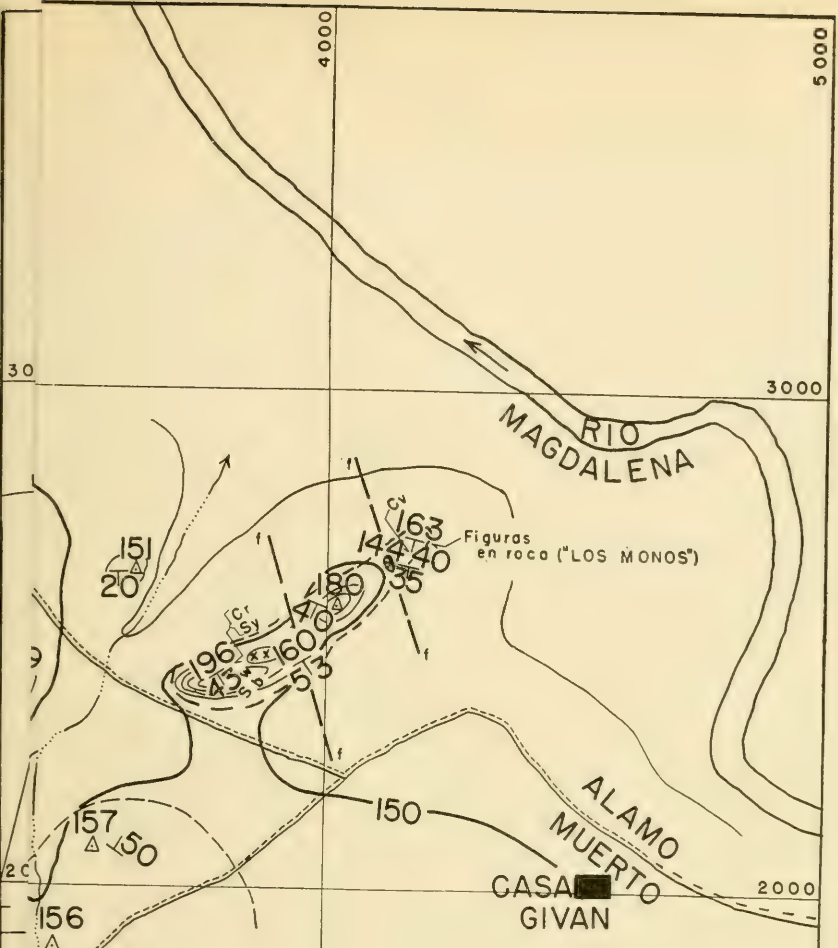
Fig. 1.—Map of part of northwestern Sonora showing location of El Antimonio and the Monos Hills (locality 806).

posed areas along a small arroyo, are shaly beds with igneous material intruded at the base. Higher, the rock continues shaly and sandy in character but in addition contains limestone lenses. No recognizable fossils were seen in the lower 900 feet of this sequence. At this point in the section bluish limestone containing black concretions produced poor productids, including *Anidanthus*. The interval between this first occurrence of *Anidanthus* and a second prominent zone containing this fossil is composed of thin-bedded reddish-gray sandy shale with yellowish limestone beds from which no fossils were taken.

The *Anidanthus* zone is exposed in several places along the east slope of the hills that lie to the west of the igneous body (156 m.), especially at the locality indicated by the dip symbol 43, and at the north angle of the hills just east of the Moreno house, and at the point D just south of it. This zone consists of 40 or 50 feet of moderately heavy bedded limestone that weathers to an orange or reddish color. Fossils are fairly common and are listed under localities 806m, n, and o. This is the lowest fossiliferous zone that could be relied on but it has only a limited extent. The other fossil zones are established in relation to this one.

Several of the succeeding zones appear at or near the Moreno house (Casa Moreno). At the point marked Dx southeast of the Moreno house and 70 feet above the *Anidanthus* zone a bed occurs containing large *Composita* and the productid *Dictyoclostus*. The latter fossil can be found to the northwest, where it occurs in the gully just east of the Moreno house and under the tank on the west side of the house. The bed is offset in places but its position above the *Anidanthus* zone is quite clear because that fossil can be found below the *Dictyoclostus* at the north point of the hill and on the northeastern tip of the hill. The *Dictyoclostus* zone contains numerous brachiopods and other fossils but all in a poor state of preservation. These species have been listed under localities 806k, k′, l, x, and z.

Parafusulina bed.—The *Dictyoclostus* zone seems to thicken or the fossils become more widely dispersed in the rock in going from the arroyo on the east side of the Moreno house to the tank on the west side of the house. From the front of the house, under the tank where the *Dictyoclostus* is most numerous, to beyond the rear of the house and part way down the hill to the north the rock abounds in bryozoans and large *Parafusulina*. This latter is often difficult to distinguish from the bryozoans on weathered rock surfaces. Since the importance of fusulines in a Permian sequence cannot be underestimated, considerable effort was made to trace this zone to other parts of the hills. This effort failed because the zone could not be followed beyond the



EXPLANATION

FIG. 2.—Map of the Monos Hills showing the Permian-Triassic boundary, position of important locations, and the location of the small igneous hill where the section of the Permian in figure 3 was started. Map drawn in meters.

east side of the Moreno house. A float piece with *Parafusulina,* found on the northeastern tip of the hill (806m), suggested a wider distribution, but the fossil was not found in place in this vicinity. It is concluded, therefore, that the *Parafusulina* is restricted to the bryozoan plantation and is a local development.

Leiorhynchoidea and Cancrinella zones.—Three to four hundred feet of reddish limestone shale and sandy limestone intervene between the *Dictyoclostus* zone and a *Composita* zone, the most prominent horizon in the upper part of the section. These reddish limestones contain two zones of fossils: the *Leiorhynchoidea* zone which occurs about 150 feet below a *Composita* zone, and a *Cancrinella* zone which includes the limestone above *Leiorhynchoidea* and below *Composita.*

The *Leiorhynchoidea* zone is not well defined, nor could it be traced satisfactorily. It is prominent on the east side of Mill Hill where specimens of *Leiorhynchoidea* are fairly abundant loose in the debris on the slope. Few other fossils occur at this level.

Most of the species assigned to the *Cancrinella* zone were found loose in the debris on the north slope of Mill Hill south of the Moreno house. This slope produced a varied fauna which must have come from the interval between the *Leiorhynchoidea* and the *Composita* zones. The complete list of species from the north slope of Mill Hill appears under locality 806i.

Composita zone.—This is such a conspicuous horizon throughout the Monos Hills that it was used as the principal reference bed in the stratigraphic work. It consists of about 20 feet of massive, impure limestone with considerable chert and quantities of silicified fossils. Chief among the fossils is *Composita grandis* which occurs in nearly every exposure of this zone.

The ease with which the *Composita* zone can be recognized made it possible to detect fossils and drifted pieces isolated from the main mass of the hills. Extensive exposures of this formation can be seen forming the ridge of the long, low elliptical hill at the east end of the Monos Hills. It is prominent at or near the crest of the high hill (394 m.) just to the west. It also is prominent near the top of the hill (295 m.) and appears on each knob of Mill Hill. Isolated small blocks of this zone appear on the east flank of hill (294 m.) and near the road just southwest of the Mill. Faunal lists are given under localities 806c, h, h′, r, v.

Spiriferellina zone.—This zone is readily recognized by the purer nature of the limestone, its bluish color, and the abundance of dark brown nodular masses of chert. The zone is 200 feet or more in thick-

ness and is generally located on the outside slopes of the crescent-shaped chain of hills. Isolated small fault blocks occur southwest of

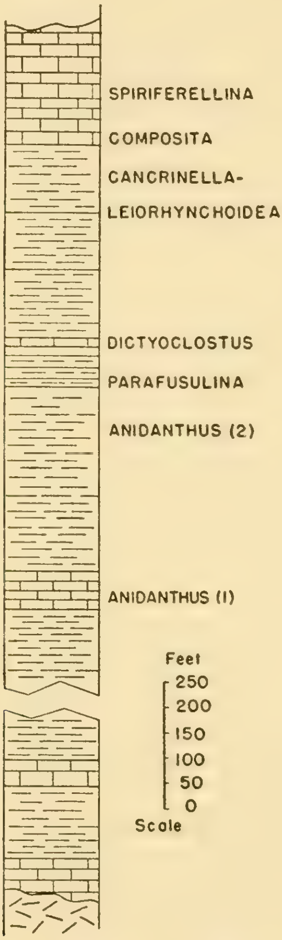


FIG. 3.—Columnar section of the Permian strata in the Monos Hills. The section is a composite one beginning at the igneous hill marked 156 on the map, figure 2. The column is broken to accommodate it to the page. The full section is 1,800-2,200 feet thick.

Mill Hill. This zone takes its name from a wide-hinged spiriferinoid that occurs in all exposures. The fossils are listed under localities 806b, d, d′, f, g, h^2, s, t, w, and y. This zone is overlain unconformably by red Triassic limestone.

PERMIAN LOCALITIES AND FOSSIL LISTS

a = abundant; c = common; rc = fairly common; r = rare; vr = very rare;
* not discussed in text.

Locality

806. Permian (Word equivalent) in Cerros de los Monos, about 1 mile northeast of El Antimonio, Sonora.

806a. *Composita* and *Spiriferellina* zones mixed, southeast side of west knob of easternmost Monos Hill, about ½ mile north of Alamo.

No species listed.

806b. *Spiriferellina* zone, south face of west knob of easternmost hill, about ½ mile northwest of Alamo.

Composita cf. *C. grandis* Cooper..................vr
**Dielasma* sp....................................r
Heterelasma contrerasi Cooper...................r
Hustedia meekana (Shumard)......................rc
Liosotella subrugosa Cooper.....................r
Marginifera, sp. 2..............................r
Spiriferellina sonorensis Cooper................c
Tetracorals=*Lophophyllidium* ....rc
Waagenoconcha montpelierensis (Girty)...........r
Wellerella lemasi minor Cooper..................c

806c. *Composita* zone, east face of large hill (elevation 294 m.), Monos Hills, about 1.2 miles west of Alamo.

Composita grandis Cooper........................a
Glossothyropsis magna Cooper....................c
Liosotella rugosa Cooper........................r
Marginifera, sp. 2..............................r
Rhynchopora taylori Girty.......................r
Spiriferellina sonorensis Cooper................r
Wellerella hemiplicata Cooper...................c
Wellerella lemasi Cooper........................a

806d. Upper *Spiriferellina* zone, knob (elevation 217 m.) just south of the south side of the high hill (elevation 294 m.), about 1.2 miles west of Alamo.

Chonetes monosensis Cooper......................c
**Dictyoclostus* sp...............................r
Euphemites subpapillosus (White)................vr
Hustedia elongata Cooper........................r
**Hustedia* sp....................................r
Liosotella subrugosa Cooper.....................rc
**Liosotella* sp..................................r
**Plagioglypta* sp................................r
Pleurotomaria(?), sp. C.........................r
Spiriferellina sonorensis Cooper................c
Sponges ....r
**Stachella* sp...................................r
Waagenoconcha montpelierensis (Girty).......... r
Wellerella lemasi minor Cooper..................r

806d'. *Spiriferellina* zone, knob with elevation 217 m., just south of south face of hill (elevation 294 m.), about 1.2 miles west of Alamo.

Composita grandis Cooper........................vr
Dielasma cf. *D. prolongatum* Girty................r
Heterelasma contrerasi Cooper....................r
Hustedia meekana (Shumard)....................r
Liosotella subrugosa Cooper......................rc
Rhynchopora taylori Girty........................r
Rhynchopora taylori rotunda Cooper...............vr
Spiriferellina sonorensis Cooper...................rc
Tetracorals = *Lophophyllidium* ....rc
Waagenoconcha montpelierensis (Girty)...........r
Wellerella lemasi minor Cooper...................rc

806e = 806s.

806f. *Spiriferellina zone,* west face southeast knob of highest hill (elevation 295 m.) south of Mill, 1½ miles northeast of El Antimonio.

Chonetes monosensis Cooper......................vr
**Chonetes* sp. ....vr
Composita grandis Cooper........................vr
**Dictyolostus* sp. ....r
Dielasma floresi Cooper..........................r
Glossothyropsis magna Cooper....................r
Heteralosia mexicana Cooper.....................vr
Heterelasma contrerasi Cooper....................r
Hustedia meekana (Shumard)....................rc
Liosotella subrugosa Cooper......................rc
Myalina sp. ....vr
Nucula sp. ....r
Orbiculoidea, sp. 1...............................vr
Pectenoid pelecypod ....vr
Rhynchopora taylori rotunda Cooper...............vr
Spiriferellina sonorensis Cooper...................c
Straparollus(?), sp. A...........................vr
Tetracorals = *Lophophyllidium* ....r
Waagenoconcha montpelierensis (Girty)...........r
Wellerella lemasi minor Cooper...................c

806g. *Spiriferellina* zone, west face of largest hill (elevation 295 m.) south of mill, 1½ miles northeast of El Antimonio.

Composita grandis Cooper........................vr
Dictyoclostus depressus subsp......................r
Dielasma floresi Cooper..........................r
Glossothyropsis magna Cooper....................r
Heterelasma contrerasi Cooper....................r
Hustedia meekana (Shumard)....................r
Liosotella rugosa Cooper.........................r
Liosotella subrugosa Cooper......................r
Plagioglypta canna (White).......................r
Rhynchopora taylori rotunda......................vr
Sponge ....r

Tetracorals = *Lophophyllidium* ....rc
Waagenoceras dieneri Böse.........................vr
Waagenoconcha montpelierensis (Girty)...........r
Wellerella lemasi minor Cooper...................c

806g′. *Composita* bed, north side largest hill south of mill (elevation 295 m.).
Glossothyropsis magna Cooper....................c

806h. *Composita* zone, southwest face of Mill Hill, about 2 miles northeast of El Antimonio.
Composita grandis Cooper.........................a
**Derbyia* sp....................................r
Glossothyropsis magna Cooper....................c
Liosotella rugosa Cooper.........................r
Marginifera, sp. 2 ....r
Pseudomartinia martinezi Cooper.................r
Rhynchopora taylori Girty........................vr
Spiriferellina sonorensis Cooper..................vr
*Tetracorals ....vr
Waagenoconcha montpelierensis (Girty)...........vr
Wellerella hemiplicata Cooper....................c
Wellerella lemasi Cooper.........................a

806h′. *Composita* zone, hill 200 yards southwest of Mill Hill, 2 miles northeast of El Antimonio.
Composita grandis Cooper.........................a
Wellerella hemiplicata Cooper....................c
Wellerella lemasi Cooper.........................a

806h². *Spiriferellina* zone, hill 200 yards southwest of Mill Hill, 2 miles northeast of El Antimonio.
Glossothyropsis magna Cooper....................r
Heterelasma contrerasi Cooper....................r
Hustedia meekana (Shumard)......................r
Liosotella subrugosa Cooper......................r
Wellerella lemasi minor Cooper...................r

806i. *Leiorhynchoidea-Cancrinella* zone, north slope of Mill Hill, $2\frac{1}{4}$ miles north-northeast of El Antimonio.
Aviculopecten montpelierensis Girty...............vr
Cancrinella phosphatica (Girty)..................rc
Chonetes foshagi Cooper..........................vr
**Composita* sp. ....r
**Dictyoclostus* sp. ....vr
Dielasma cf. *D. spatulatum* Girty.................vr
Glossothyropsis magna Cooper....................r
Hustedia meekana (Shumard)......................r
Hustedia meekana plicatella Cooper................rc
Leiorhynchoidea cloudi Cooper....................r
Liosotella magnirugosa Cooper....................r
Liosotella rugosa Cooper.........................r
Muirwoodia sp. ....r
Nucula, 2 sp.....................................vr
Nuculana obesa White.............................r
Omphalotrochus (?), sp. A.........................vr

Orbiculoidea, sp. 2 .... r
Pleurophorus sonorensis Cooper .... r
Pleurotomaria, (?) sp. A,B .... vr
Punctospirifer convexus Cooper .... vr
Rhynchopora taylori Girty .... r
Spiriferella, sp. 1 .... vr
Spiriferellina laxa (Girty) .... r
Stenoscisma sp. .... vr
Uncinunellina? pulchra Cooper .... vr
Waagenoconcha montpelierensis (Girty) .... r
Wellerella lemasi Cooper .... r
Wellerella rotunda Cooper .... r
Wellerella sp. .... r

806i′. *Leiorhynchoidea* zone, north slope of Mill Hill.

Leiorhynchoidea cloudi Cooper .... rc

806j. *Parafusulina* bed, north side of tank and northwest side of Moreno House. 2¼ miles north-northeast of El Antimonio.

Parafusulina antimonioensis Dunbar .... a
*Bryozoa .... a

806k. *Dictyoclostus* zone, under water tank on west side Moreno house, 2¼ miles north-northeast of El Antimonio.

Chonetes gibberulus Cooper .... r
Composita grandis Cooper .... r
Dictyoclostus depressus Cooper c
**Euphemites* sp. .... vr
**Hustedia* sp. .... r
**Liosotella* sp. .... r
Marginifera, sp. 1 .... r
Muirwoodia sp. .... vr
Neospirifer, sp. 1 .... r
Neospirifer, sp. 2 .... r
Spiriferella, sp. 1 .... r
Spiriferellina laxa (Girty) .... r
Spiriferellina sonorensis Cooper .... vr
Streptorhynchus sp. .... vr
*Tetracorals .... r
Waagenoconcha montpelierensis (Girty) .... r

806k′. *Dictyoclostus* bed, drift fossils from *Dictyoclostus* bed in vicinity of Moreno house, 2¼ miles north-northeast of El Antimonio.

Composita grandis Cooper .... r
Dictyoclostus depressus Cooper c
Liosotella rugosa Cooper .... r
Marginifera, sp. 1 .... r
Plagioglypta canna (White) .... r
Spiriferellina laxa (Girty) .... vr
Spiriferellina sonorensis Cooper .... r
Stenoscisma sp. .... vr
Streptorhynchus sp. .... vr
Waagenoconcha montpelierensis (Girty) .... r
*Bryozoans c

806-l. *Dictyoclostus* zone, arroyo just east of Moreno house, 2¼ miles north-northeast of El Antimonio.

Chonetes gibberulus Cooper..........................vr
Dictyoclostus depressus Cooper....................rc
**Liosotella* sp. ....r
Marginifera, sp. 1.......................................r
Muirwoodia sp. ....vr
Rhynchopora taylori Girty.........................vr
Streptorhynchus sp. ....vr
Waagenoconcha montpelierensis (Girty)..........r

806m. *Anidanthus* zone, north end of low hill east of Moreno house, 2¼ miles north-northeast of El Antimonio.

Anidanthus alatus Cooper..........................a
Derbyia arellanoi Cooper..........................r
Derbyia elongata Cooper...........................vr
Dictyoclostus depressus Cooper..................c
Liosotella rugosa Cooper..........................rc
**Neospirifer* sp. ....r
Orthonychia, sp. A......................................r
Parafusulina sp. ....vr
Plagioglypta canna (White)........................r
Rhynchopora taylori Girty.........................r
Schizodus parvulus Cooper........................r
Spiriferella? scobinoidea Cooper.................c
Sponges ....r

806m'. First *Composita* zone = *Dictyoclostus* zone, center east side of hill east of Moreno house, 2½ miles north-northeast of El Antimonio.

**Composita* sp. ....r
Dictyoclostus depressus Cooper...................c
Plagioglypta canna (White)........................r
Streptorhynchus sp. ....r

806n. *Anidanthus* zone, east slope largest hill (295 m.) south of Mill Hill, 2 miles northeast of El Antimonio.

Anidanthus alatus Cooper..........................a
Derbyia arellanoi Cooper..........................r
Derbyia elongata Cooper...........................r
Dictyoclostus depressus Cooper..................r
Liosotella angustata Cooper......................r
Liosotella rugosa Cooper..........................r
Rhynchopora taylori Girty.........................r
Schizodus parvulus Cooper........................r
Spiriferella? scobinoidea Cooper.................r
Spiriferella, sp. 2.......................................r
Sponge ....vr
Waagenoconcha montpelierensis (Girty)...........rc

806-o. *Anidanthus* zone, hill about 0.4 mile 170° south of east knob of Mill Hill. 2 miles northeast of El Antimonio.

Anidanthus alatus Cooper..........................a
Derbyia arellanoi Cooper..........................r
Dictyoclostus depressus Cooper..................rc
**Hustedia* sp. ....r

Liosotella angustata Cooper......................vr
Pleurophorus sp. ....r
Schizodus parvulus Cooper......................r
Waagenoconcha montpelierensis (Girty)..........r

806p. First *Composita* zone = *Dictyoclostus* zone, 30 feet above the *Anidanthus* zone on top of small hill just south of the hill east of the Moreno house, 2¼ miles north-northeast of El Antimonio.

Composita grandis Cooper......................rc
**Derbyia* sp. ....r
**Dictyoclostus* sp. ....r
**Rhynchopora* sp. ....r
Spiriferellina sonorensis Cooper..................r
Waagenoconcha montpelierensis (Girty)..........r

806q. *Leiorhynchoidea* zone, east face of largest hill elevation (295 m.) south of Mill Hill, 1½ miles northeast of El Antimonio.

Leiorhynchoidea cloudi Cooper....................a
Uncinunellina? *pulchra* Cooper....................r

806r. *Composita* zone, north side of west knob of easternmost hill of Monos Hills, ½ mile north of Alamo.

Composita grandis Cooper........................a
Liosotella rugosa Cooper........................r
Marginifera, sp. 2..............................r
Pseudomartinia martinezi Cooper................r
Rhynchopora bicostata Cooper....................vr
Rhynchopora taylori Girty........................vr
Wellerella hemiplicata Cooper....................r
Wellerella lemasi Cooper........................c

806s. *Spiriferellina* zone, reentrant in hills east-northeast of El Antimonio, 1½ miles east-northeast of El Antimonio.

Hustedia meekana (Shumard)....................rc
Liosotella subrugosa Cooper......................r
Spiriferellina sonorensis Cooper..................rc
Tetracoral = *Lophophyllidium* ....rc
Wellerella lemasi minor Cooper..................c

806t. Highest Permian, fault block in arroyo about 0.6 mile south-southwest of Mill, 1½ miles northeast of El Antimonio.

Dictyoclostus depressus Cooper..................r
Warthia, sp. A..................................vr

806u. *Leiorhynchoidea* zone, 130 feet below *Composita* bed in east face of Mill Hill, 2½ miles north-northeast of El Antimonio.

Leiorhynchoidea cloudi Cooper....................c

806v. *Composita* zone, small knob at the easternmost end of Monos Hills, ½ mile north of Alamo.

Composita grandis Cooper........................a
Liosotella rugosa Cooper........................r
Rhynchopora taylori Girty........................vr
Wellerella lemasi Cooper........................c

806w. *Spiriferellina* zone, top of west knob of the hill due west of the easternmost hill, Monos Hills, ½ mile north of Alamo.

Glossothyropsis magna Cooper....................r

Heterelasma contrerasi Cooper....................r
Hustedia meekana (Shumard)....................rc
Liosotella subrugosa Cooper.........................r
**Spiriferellina* sp. ....r
Tetracoral = *Lophophyllidium* ....rc
Wellerella lemasi minor Cooper..................c

806x. *Dictyoclostus* zone, east slope of knob just east of east slope of Mill Hill, 2½ miles north-northeast of El Antimonio.

Composita grandis Cooper.........................rc
Dictyoclostus depressus Cooper..................r
Liosotella rugosa Cooper.........................r
Spiriferellina sonorensis Cooper..................r

806y. *Spiriferellina* zone?, lower 3 feet of sandstone just above the *Composita* zone, easternmost Monos hill, ½ mile north of Alamo.

Glossothyropsis magna Cooper....................r
Hustedia meekana (Shumard)....................r
**Marginifera* sp. ....r

806z. *Dictyoclostus* zone, float from east side of the hill east of the Moreno house, 2½ miles northeast of El Antimonio.

**Anidanthus* sp. c
*Bryozoa c
Composita grandis Cooper.........................r
Dictyoclostus depressus Cooper....................c
**Plagioglypta* sp. ....r
Waagenoconcha montpelierensis (Girty)..........r

Unnumbered. *Spiriferellina* zone, top of east knob of Mill Hill, about 2 miles northeast of El Antimonio.

Waagenoceras dieneri Böse......................vr

Abbreviations for repository for type specimens used in text and plate legends:

U.S.N.M. = United States National Museum.
I.G.M. = Instituto Geológico de México.

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A GIANT PERMIAN FUSULINE FROM SONORA

By CARL O. DUNBAR

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(Plates 2 and 3)

I am indebted to Dr. G. Arthur Cooper for entrusting me with the study of the fusulines that he collected from the Permian rocks near El Antimonio, northwestern Sonora. They are from a single bed of compact, brownish-gray, rusty weathering limestone about 3 feet thick (loc. 806j). In this layer they occur in great abundance, making up 10 percent or more of the volume of the rock. They appear to belong to a single species described below as *Parafusulina antimonioensis*, new species. It is an uncommonly large, slender fusuline of which some of the microspheric shells may have reached a length of 4 inches, far exceeding any fusuline previously described.

The fusulines lie more or less at random and are tightly enclosed in hard matrix so that none can be freed. As exposed on the weathered surfaces, they appear rather unpromising, but when sectioned the preservation is found to be good. Their study is handicapped, however, by the fact that the majority were broken before burial and even those that were intact commonly were fractured across the middle during compaction of the enclosing sediment. As is common with large and slender species, the axis was seldom quite straight during growth and not uncommonly it was decidedly irregular and even strongly bent at the middle. Furthermore, many of the shells suffered some distortion during compaction. It is generally impossible, therefore, to make axial sections that are correctly oriented from pole to pole. If the shells were free one could select those that are curved or bent in a single plane and cut the section in this plane with good results, but since they are enclosed in compact dark matrix it is usually difficult to determine this orientation in time to get the most perfect section. Fortunately, it is not too difficult to get good orientation in one end of a shell which permits measurement of the radius vector and half length, from which the approximate over-all dimensions can be inferred.

PARAFUSULINA ANTIMONIOENSIS Dunbar, new species

(Plate 2, figures 1-8; plate 3, figures 1-3)

Description.—This fine species shows such marked dimorphism that megalospheric and microspheric forms must be described separately. Although microspheric shells are relatively abundant, they are outnumbered probably 100 to 1 by the megalospheric form.

Megalospheric form.—Adult megalospheric shells commonly have 8 to 9 volutions (rarely 10) and attain a diameter of 4.5 to 5.0 mm. and a length of 25.0 to 30.0 mm. (rarely more). The form ratio increases during growth, at least up to the seventh volution, the length being 3 to 4 or 5 times the thickness in the early whorls but increasing to 7 or more (even up to almost 11) times the diameter in the final whorls. The axis is commonly somewhat crooked, and occasionally is strongly arched or even rather sharply bent at the middle.

The proloculi are large and commonly are spheroidal and have a firm wall 30 to 40 microns thick. In our best sections several of the spheroidal proloculi each have a diameter near 600 microns, but one (pl. 2, fig. 7) is elliptical and only 385 microns in lesser diameter and 500 in the greater. A few are strongly flattened (pl. 2, fig. 6) or decidedly irregular (pl. 3, fig. 1).

The volutions are low and tightly coiled across the middle of the shell, rising rapidly in height near the poles, and the spiral wall is thin, as indicated in the table of measurements, scarcely exceeding 70 microns even in the outer whorls. It is distinctly alveolar as is normal in this genus.

The septa are intensely and regularly folded from pole to pole, and cuniculi are well developed throughout the shell. They appear early in the ontogeny, being recognizable even in the first volution, and in the later whorls they are so large, as compared with the septal folds, as to be conspicuous in any tangential or oblique slice (pl. 2, figs. 5 and 8). Septal pores are abundant but are commonly not conspicuous because the intense folding leaves only thin septal loops in thin sections.

The tunnel is narrow and commonly can hardly be detected in thin axial sections, for chomata are completely lacking at all stages of growth. The scattered records of the tunnel angle given in the table of measurements are all that could be determined with reasonable accuracy in these 5 specimens. Specimens 3 and 5 were fractured across the tunnel after burial so that no satisfactory measurement could be taken, and in the others the actual margins of the tunnel could only be recognized in a few whorls. An unbroken row of septal

loops demonstrates that no tunnel was present in the entire outer whorl (e.g., pl. 3, fig. 1).

A slender and somewhat irregular zone of axial filling is normal for the species, as is well shown in figure 1 of plate 2 and figures 2 and 3 of plate 3. In case an axial section is even slightly oblique, as

Table of measurements

Volution	Half length			Radius vector				Form ratio	
	No. 1	2	3	1	2	4	5	1	2
0	.029	.030	.030	.029	.030	.030	?	...	...
1	.090	.10	.10	.037	.040	.043	.037	...	...
2	.16	.24	.16	.046	.050	.056	.050	3.5	4.8
3	.31	.36	?	.057	.059	.070	.067	5.4	6.0
4	.41	.57	.40	.073	.074	.088	.081	5.6	7.7
5	.59	.85	.54	.089	.090	.110	1.03	6.6	9.0
6	.77	1.10	.74	.107	?	.134	1.28	7.2	...
7	.97	1.31	.96	.134	.125	.157	1.50	7.2	10.4
8	1.20	1.65	1.08+	.175	.152	.190	?	6.8+	10.8
9	...	?	1.20+	...	?	...	...	...	...

Volution	Tunnel angle				Wall thickness				Septal count	
	No. 1	2	3	4	1	2	3	4	6	7
0	...	...	...	...	.036	.025	.030	.043	...	...
1	...	...	...	...	?	.030	.030	.045	16	16
2	...	...	...	...	?	.038	.043	.045	25	29
3	...	18°	...	...	.043	.043	?	.047	28	?
4	...	...	...	...	?	.045	.045	.057	36	?
5	...	23°	...	...	.057	.070	.045	.065	?	?
6	...	24°	...	27°	.070	.070	.057	.065	36	?
7	26°	...	...	...	.077	.070	.057	.070	45	42
8	...	...	...	...	?	.060	.070	?	45	?
9	...	...	...	...	...	...	.070	...	?	...

Specimen No. 1, figure 1, plate 2; No. 2, figure 3, plate 3; No. 5, figure 1, plate 3; No. 6 and No. 7, figures 7 and 6 of plate 2.

in figure 1 of plate 3, the axial filling is largely missed. In this case, also, the obliquity causes considerable foreshortening at the poles, and the section appears quite abnormal. Sagittal sections show that the whorls are low and tightly coiled and the chambers slender. We experienced considerable difficulty in counting the septa in some of the volutions.

Microspheric form.—Although a score or more of microspheric shells are present in the material studied, all but one appear to have been broken into isolated pieces before burial. The immature specimen shown at natural size in figure 2 of plate 2 was intact except that its

exposed surface was deeply eroded. This photograph was taken after it had been ground down to approximately the axis. Figure 4 of plate 2 shows the middle part of this specimen in thin section at a magnification of 10 diameters. This shell, with about 15 volutions and a diameter of 4.6 mm., had a length of 62 mm., being more than 13 times as long as thick. Fragments of much larger shells indicate that this one was only about half grown. The one shown as figure 5 on plate 2, for example, has a diameter of 7.0 mm. More than half of this piece had weathered away so that we could get only a tangential slice that does not indicate the full number of volutions. Another specimen having a diameter of 8.0 mm. is 36 mm. long, with both ends broken away, and this part is almost cylindrical. If its form ratio was like that of the whole specimen described above, its original length was over 10 cm. or approximately 4 inches. Unfortunately this specimen was weathered so deeply that we could get only a tangential slice.

The specimen represented by figure 4 of plate 2 shows well the proloculus and early whorls of a microspheric shell. The proloculus has a diameter of only 60 microns and its wall is only about 5 microns thick. It is followed by a little more than one volution of globular chambers coiled in the plane of this slice (i.e., at right angles to the axis of later whorls). Following this small juvenarum there is a rapid change in the plane of coiling accompanied by polar elongation. The first postjuvenarial whorl has a diameter of 36 microns and a length of 90 microns. Its spiral wall has a thickness of about 15 microns and its septa were only gently folded. The second volution has a thickness of 40 microns and a length of 180 microns. In the early half of this volution the septa appear not to have been strongly folded, but in the latter half the strong, regular septal loops agree with those of later whorls indicating strong septal folding.

Unlike the megalospheric shells, the microspheric ones show no clear evidence of a tunnel at any stage of growth although it is possible that the narrow space between the two median septal loops in the first two or three volutions may represent a tunnel in the earliest whorls preceding the development of cuniculi.

Microspheric shells have a slender zone of axial filling essentially like that of the megalospheric.

Cuniculi are well developed in all but the very earliest whorls (e.g., fig. 5 of pl. 2). Unfortunately we did not succeed in determining just where they begin. The dark matrix and the extremely small size of the early whorls conspire to make it difficult to see these features in a thick slice as the proloculus is approached.

Types.—Holotype, U.S.N.M. No. 123301; figured paratypes, U.S.N.M. Nos. 123302a-h.

Discussion.—It is a striking fact that although the tunnel is an invariable family character so far as megalospheric fusulines are concerned, it is never found in microspheric shells of the genera *Parafusulina* and *Polydiexodina*. We infer from this that these microspheric giants had many small nuclei instead of a single large one and that the cuniculi therefore afforded adequate passageway for them to migrate to the outer volutions during growth. It is known, for example, that the tunnel is a secondary feature produced by resorption of a part of the septa (Dunbar and Henbest, 1943, p. 45), and it appears to have been a necessary opening to allow migration of the nucleus so as to keep near the center of mass of the protoplasm during growth. But if the nuclei were quite small the cuniculi would afford adequate passage and resorption of a tunnel would be superfluous.

Parafusulina antimonioensis needs comparison with only a few of the largest known species of the genus. It resembles *P. deliciasensis* Dunbar and Skinner (syn. *P. maleyi* var. *referta* Dunbar and Skinner) in general shape, in size of proloculi, in the slender zone of axial filling, and in the very advanced development of its cuniculi; but it is much larger and more elongate. The megalospheric shells of the new species attain almost twice the length of *P. deliciasensis* and have more numerous and more tightly coiled volutions, but the greatest difference is seen in the microspheric shells which are extremely slender in *P. deliciasensis* and are two or three times as thick in the new species.

P. virga Thompson and Wheeler, from the Nosoni formation of California, resembles our new species in the stage of its septal evolution and in its axial filling, but that species is more loosely coiled and has fewer volutions at corresponding dimensions and it is smaller and much shorter.

P. californica (Staff) of the Nosoni formation is also much more loosely coiled and is shorter and blunter at the poles.

Geologic age.—These fusulines were first sent to me unlabeled and I was asked by Dr. Cooper to determine their age as best I could without any field data whatever. After making a few sections I replied without hesitation that they were of Word age, that is, of the age of the lower part of the Guadalupian series of the American Permian. This age is indicated by several features, but especially by the stage of evolution of the cuniculi. Although the genus *Parafusulina* appears low in the Leonardian and ranges up through the lower half, at least, of the Guadalupian, the cuniculi are not so fully developed in

any of the Leonardian species. In the evolution of this genus out of *Schwagerina,* cuniculi appear first in the outer volutions only, and across the middle part of the shell. Furthermore they are very low and narrow openings in the early species and can be detected only in tangential slices very close to the floor of a volution. In the phylogenetic history of the tribe the cuniculi appear earlier and earlier in ontogeny and spread progressively toward the poles of the shell. Concurrently the septal arches that form the cuniculi become both higher and wider until they occupy almost the full width of a septal fold and almost half the height of the septum. At this stage of evolution the cuniculi are conspicuous in any tangential slice, as they are in figures 5 and 8 of plate 2. At a still later date well up in the Guadalupian, supplementary tunnels began to break through the septa giving rise to the genus *Polydiexodina.* In the Guadalupian Basin *Parafusulina* appears to be abruptly replaced by *Polydiexodina* at the base of the Upper Delaware Mountain (Bell Canyon) sandstone, and the same is true in the Las Delicias region of Mexico. It is to be expected, however, that the ancestral genus, *Parafusulina,* persisted in some parts of the world after the appearance of *Polydiexodina* and that the two genera will be found associated in the highest Permian strata. Indeed, I have seen collections from Persia and from Afghanistan where the two genera do occur together.

Since the cuniculi are highly developed in *P. antimonioensis,* appearing even in the first volution of megalospheric shells, the age of the species can hardly be older than Guadalupian, and since *Polydiexodina* is not present, the age is probably lower Guadalupian. The enormous size and extreme dimorphism strongly confirm the Guadalupian age.

The collections studied are from a thin limestone bed just below the *Dictyoclostus* zone at the Moreno house, loc. 806j, 2¼ miles north-northeast of El Antimonio.

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CORALS

By HELEN DUNCAN

United States Geological Survey

(PLATE 23C, FIGURES 27, 28)

(Tetracorals are common in the *Spiriferellina* zone but they are coarsely silicified. Dr. Helen Duncan, of the U. S. Geological Survey, kindly furnished the following information.—G.A.C.)

The collections submitted contain 11 specimens of horn corals. All are rather severely beekitized. In the three specimens that were sectioned, original skeletal structures were found to be partly obliterated, and it is possible that certain diagnostic features have been destroyed. Owing to their imperfect preservation, the specimens cannot be accurately identified as to genus or species.

Most of the specimens in lots 806b, d′, f, s, and w appear to belong to the same species and are tentatively referred to *Lophophyllidium?* species undetermined. It is possible that these corals are identical with or closely related to *Malonophyllum texanum* Okulitch and Albritton, 1937, described from the Leonard of Texas. The genus *Malonophyllum* was based on silicified material, which fails to give adequate information regarding internal features and microscopic structural detail. The genus is supposed to differ from *Lophophyllidium* in lacking tabulae; however, it is not uncommon to find that tabulae are partly or entirely destroyed in silicified specimens, and I do not think that the original absence of tabulae has been or can be proved from a study of the type material. I agree with Jeffords that *Malonophyllum* cannot be positively recognized and expect that the genus ultimately may be referred to the synonymy of *Lophophyllidium.* The specimens from Mexico are somewhat larger than *Malonophyllum texanum* but have about the same number of septa—considerably more than reported in other Permian species of lophophyllids described from North America.

SPONGES, BRACHIOPODA, PELECYPODA, AND SCAPHOPODA

By G. ARTHUR COOPER

United States National Museum

(Plates 4-22; plate 23, figures 1-26, 29-33; plate 24, figures 1-20; plate 25, figure 14)

SPONGES

Plate 23E, figure 33

At several localities poorly preserved sponges were seen but none of the specimens collected proved good enough for description. One fragment showing hexactin spicules is illustrated.

Figured specimen.—U.S.N.M. No. 116638.

Horizon and locality.—*Anidanthus* zone, loc. 806m, n.

In the *Spiriferellina* zone, especially on the west slope of the large hill (294 m.) south of the mill, large brown tubular objects in the rock are probably sponges but none were taken that preserved good interior details.

Horizon and locality.—*Spiriferellina* zone, loc. 806g.

BRACHIOPODA

ORBICULOIDEA, species 1

Plate 4C, figure 8

Represented by an impression of a brachial valve which is small, conical in profile, suboval in outline; margins rounded; apex eccentric, located about 1 to 2 mm. anterior to the posterior margin. Umbo swollen and convex; anterior gently swollen and with a long gentle slope to the anterior margin. Posterior slope short and steep.

Measurements in mm.—Length 8.5 plus, width 8.1 plus, height ca. 1.0.

Figured specimen.—I.G.M.

Horizon and locality.—*Spiriferellina* zone, loc. 806f.

Discussion.—This specimen is not very well preserved. Cloud figures a new species, *O. ovalis* from the *Waagenoceras* zone in the Las Delicias area, Coahuila, which agrees in the proportions and other de-

tails of the brachial valve. In the absence of a pedicle valve it is not possible to make a positive identification although Cloud's species is associated with *Waagenoceras*. The Monos species occurs with the same cephalopod.

ORBICULOIDEA, species 2

Plate 4A, figures 1, 2

A single brachial valve is conical in profile, subcircular in outline, all margins strongly rounded; beak subcentral with gently swollen umbonal region; highest point on cone a short distance anterior to beak; anterior slope long and moderately steep; lateral slopes steep, making an angle slightly greater than a right angle with the crest; posterior slope gently concave, steep.

Measurements in mm.—Length 25.0, width 24.5, height ca. 6.0, distance of apex from posterior margin ca. 9.0.

Figured specimen.—I.G.M.

Horizon and locality.—*Cancrinella* zone, loc. 806i.

Discussion.—The unusually large size relates this specimen to *Orbiculoidea utahensis* (Meek) but the specimen is too incomplete to make an identification certain.

DERBYIA ARELLANOI Cooper, new species

Plate 5, figures 1-12

Shell of about medium size for the genus, variable, transversely subelliptical in outline, valves unequally convex, the brachial valve having the greater depth. Hinge narrower than the greatest width which is near the middle. Cardinal extremities obtusely angular. Anterior commissure rectimarginate. Anterolateral margins strongly convex; anterior margin broadly convex. Surface costellate, costellae subequal in size and appearing in five or six generations by intercalation about 5 mm. apart except for anterior 15 mm. where intercalations are rare. Costellae narrowly rounded and separated by furrows of nearly equal size to the costellae posteriorly but anteriorly more crowded. Costellae numbering 12 in 5 mm. at 10 mm. anterior to the beak, 10 in 5 mm. at 20 mm. from beak, 8 in 5 mm. at 30 mm. from beak, and 8 to 9 in the space of 5 mm. along the anterior margin. Concentric wrinkles present on both valves, most prominent on pedicle valve.

Pedicle valve depressed semiconical in lateral profile but broadly convex in anterior profile. Beak small, usually somewhat distorted. Umbo irregular; median portion somewhat inflated in old specimens but quite flat in young. Slopes to cardinal extremities concave, mod-

erately steep. Interarea apsacline, moderately long, nearly flat; pseudodeltidium narrow, but strongly convex.

Brachial valve unequally convex in lateral profile, the greatest convexity located in the umbonal region; anterior profile strongly convex particularly in the median portion and with long, steep, gently concave slopes. Umbonal region moderately strongly inflated and projecting slightly posterior to the posterior margin. Umbonal slopes concave, steep. Median and anteromedian regions moderately swollen and with moderately steep slopes to the lateral margins. Anterior slope long, gently convex, not very steep.

Pedicle valve provided with short median septum extending to about the middle of the valve. Brachial interior with short cardinal process having short but strong lateral plates supporting it. Cardinal process unusually small for a large shell.

Types.—Holotype, U.S.N.M. No. 115473; figured paratypes, U.S.N.M. Nos. 115474a, b, I.G.M.; unfigured paratype, U.S.N.M. No. 115474c.

Measurements in mm.—Holotype, length 45.7?, midwidth 58.5, hinge width 44.0, thickness 27.0, width of pseudodeltidium at base 11.7.

Named in honor of Ing. Alberto Arellano, my coworker on Sonora geological problems.

Horizon and locality.—*Anidanthus* zone, loc. 806m, 806n, 806-o.

Discussion.—This species resembles *D. regularis* McKee from the Beta member of the Kaibab limestone, Grand Canyon, Ariz., but differs in having a more inflated brachial valve, and more closely crowded costellae. It also has a slight resemblance to *Orthotetes sulcus* Branson which belongs to the genus *Derbyia* in its general form and type but the Mexican species does not have the deep brachial sulcus or deeply concave pedicle valve of the Phosphoria species.

DERBYIA ELONGATA Cooper, new species

Plate 4B, figures 3-7

Shell of about medium size for the genus, longer than wide, with longitudinally suboval outline, valves very unequal in depth, the pedicle valve having the greater depth. Hinge narrower than the greatest width which is somewhat anterior to the middle. Anterior commissure rectimarginate. Surface costellate. Costellae subequal, separated by furrows of equal or greater width to the costellae. Nine costellae in 5 mm. at the middle and 10 in the same space at the front of the shell. Growth undulations distant but strong.

Pedicle valve hemiconical in lateral profile with the beak and palintrope elongated; anterior profile subtriangular. Umbonal region swollen with long and steep, gently convex slopes. Median and anterior regions somewhat depressed. Anterolateral areas narrowly rounded and with very steep slopes to the margin. Interarea long and narrow, nearly flat. Pseudodeltidium wide, not strongly elevated.

Brachial valve moderately convex with the greatest convexity in the umbonal region in lateral profile but broadly and gently convex in anterior profile. Umbonal region moderately swollen; median region apparently gently swollen. Lateral slopes to the margins not very steep.

Pedicle interior with extremely large, strong, and curved teeth and stout dental ridges. Median septum high, thin, but thickening posteriorly, terminating posteriorly in a callosity in the apex of the delthyrial chamber. Median septum extending anteriorly almost to the front margin. Muscular field very large, the diductor scars flabellate and occupying nearly the entire inner surface of the valve. Brachial interior with unusually large and flaring lateral plates supporting the cardinal process which is not clearly visible in the specimen studied.

Types.—Holotype, U.S.N.M. No. 115589; paratype, U.S.N.M. No. 115475.

Measurements in mm.—Holotype, length 33, width at middle (based on half measure of 14.7) 29.4, hinge width (based on half measure of 10.8) 21.6, thickness through the posterior 23.5, length of interarea ca. 12.0; paratype, length ca. 41.0, midwidth 33.0, hinge width 32.8, thickness 17, length of interarea 20.6.

Horizon and locality.—*Anidanthus* zone, loc. 806m, 806n.

Discussion.—This species is quite unlike any described American Permian species in the extremely long median septum and the greatly expanded, flabellate diductor scars that occupy nearly the entire floor of the pedicle valve.

STREPTORHYNCHUS species

Plate 4D, figures 9-13

Four specimens, all imperfect, are doubtfully referred to this genus. In the absence of a brachial valve it is impossible to tell the true nature of the genus, but the absence of dental plates in the pedicle valve and the fine radial ornamentation suggest the genus *Streptorhynchus*. A composite description of the material follows:

Elongate-ovate in outline with the greatest width at or near the middle; hinge narrower than the greatest shell width; lateral margins strongly rounded; anterior margin broadly rounded. Surface multi-

costellate; costellae narrowly rounded, separated by furrows equal in width to the costellae; 11 or 12 costellae in 5 mm. at the front margin. Irregular concentric wrinkles also occur on the body of the shell.

Pedicle valve subsemiconical, gently convex in lateral profile with the greatest convexity located in the posterior half. Anterior profile broadly convex. Umbonal region gently swollen, but anterior half of valve slightly convex to somewhat flattened. Umbonal slopes steep but lateral and anterior slopes only moderately steep. Interarea moderately long, flat, apsacline. Delthyrium covered by a low pseudodeltidium.

Interior with a narrow but moderately deep delthyrial cavity. Dental plates absent but dental ridges thick and stout, fused to sides of delthyrial cavity by callus. Muscular area ovate; diductor scars long and large, flabellate, broad; adductors small.

Figured specimens.—U.S.N.M. Nos. 115523, 115524a, b.

Measurements in mm.—Figured specimen, U.S.N.M. No. 115524a, length 52.0 but at least 10 mm. missing, width 51.0 but incomplete; figured specimen, U.S.N.M. No. 115524b, length and width incomplete, hinge width 36.0.

Horizon and locality.—*Dictyoclostus* zone, loc. 806k, 806k′, 806-l, 806m′.

CHONETES FOSHAGI Cooper, new species

Plate 6B, figures 8-12

Shell small for the genus, wider than long, subrectangular in outline; concavo-convex. Hinge narrower than the greatest shell width which is at about the middle. Hinge line straight; lateral margins obtusely rounded; anterior margin gently convex. Anterior commissure fairly strongly uniplicate. Surface finely costellate, costellae rounded, separated by fine furrows, about 5 costellae in 1 mm. at the anterior margin.

Pedicle valve barely perceptibly convex in lateral profile; very gently and broadly convex in anterior profile. Umbonal region moderately swollen and meeting the posterior margin at the beak. Sulcus originating on the umbo, suddenly deepening and widening and extending to the anterior margin. Sulcus bounded on each side by a strong plication extending from the umbo to the anterolateral margins. Cardinal extremities flattened, the low area continuing to the plication and set off from the latter by a shallow oblique groove. Umbonal slopes short but steep. Interarea short, apsacline. Beak small.

Brachial valve gently concave in lateral profile and broadly concave in anterior profile. Umbonal and median areas concave; median area rising anteriorly to form a moderately elevated, broad fold in the

anterior half. Fold bounded on each side by oblique sulci, deep at the rear but becoming shallower anteriorly. Posterolateral areas gently concave and separated from the oblique sulci by low ridges extending from the beak to the middle of the lateral margin. Interarea short, hypercline.

Measurements in mm.—Holotype, length 9.4, midwidth (based on half measure of 8.2) 16.4, hinge width (based on half measure of 7.5) 15.0, thickness at middle 1.8, surface length 9.5.

Holotype.—U.S.N.M. No. 115506.

Horizon and locality.—*Leiorhynchoidea-Cancrinella* zone, loc. 806i.

Discussion.—This species is represented in the collection by a single specimen only, and may be distinguished from other species of the genus in this area by its extremely flattened pedicle valve, the strong median fold on the pedicle valve and deep concave area at the posterior of the brachial valve. King figures no comparable species from the Glass Mountains and none like it is yet known from the Phosphoria formation of the United States.

CHONETES GIBBERULUS Cooper, new species

Plate 6D, figures 23-27

Shell of about medium size for the genus, longer than wide with a subrectangular outline; hinge slightly narrower than, or about equal to, the greatest shell width which is at about the middle. Cardinal extremities slightly auriculate. Anterior commissure strongly uniplicate. Surface multicostellate, costellae fine, narrowly rounded, crowded and separated by furrows narrower than the costellae. About 6 costellae to 1 mm. at the front margin.

Pedicle valve strongly and evenly convex in lateral profile and with the greatest curvature at about the middle. Anterior profile broadly convex with short steep sides, forming a depressed broad arch indented in the middle by a shallow furrow. Umbonal region slightly swollen and medially depressed by the sulcus which takes its origin at this point. Median sulcus broad and shallow, extending to the anterior margin. Sulcus bounded on each side by a low, narrowly rounded plication most prominent in the median region and extending from the umbo to the anterolateral margin where it is indistinct. Umbonal slopes gently convex, very steep; lateral slopes steep but less so than the umbonal slopes; anterior slope unusually steep. Interarea of about usual length and width in the genus, narrowly curved, anacline.

Brachial valve molded into the pedicle valve, thus deeply concave, with a concave umbonal region. Anterior profile broadly concave. Median region very deep with concavity lessening laterally and anteri-

orly to the steep sides deflected toward the brachial valve, which surround the inner concavity. Median fold low and broad originating at about the middle. Cardinal extremities flattened to sulcate. Interarea short, plane, hypercline.

Measurements in mm.—Holotype, length 12.0, midwidth (based on half measure of 8.0) 16.0, hinge width (based on half measure of 7.3) 14.6, thickness at middle 2.8, surface curvature 18.5 mm.; paratype (I.G.M.), length 11.0, midwidth (based on half measure of 7.7) 15.4, hinge width (based on half measure of 7.2) 14.4, thickness ?, curvature 19.0.

Types.—Holotype, U.S.N.M. No. 115504; paratype, I.G.M.; unfigured paratypes, U.S.N.M. Nos. 115503, 115505.

Horizon and locality.—*Dictyoclostus* zone, loc. 806k, 806-l.

Discussion.—This is an uncommon species and appears to be confined to the lower part of the column in the Monos Hills. The species is characterized by its strongly convex pedicle valve, the slight cardinal auriculations, and narrow but prominent sulcus in the pedicle valve. It is unlike any other chonetid in this region and seems to be related somewhat remotely to *C. subliratus* Girty. That species however possesses acutely angular cardinal extremities, a narrower sulcus, much more abrupt and steep lateral slopes and much fuller umbonal region. The chonetids of the Word formation of the Glass Mountains identified by King as *C. subliratus* are mostly larger shells than *C. gibberulus.* Cloud indicates no chonetid from Coahuila even remotely related to this species.

CHONETES MONOSENSIS Cooper, new species

Plate 6E, figures 28-34

Shell of about medium size for the genus, transversely subrectangular to semielliptical in outline, the hinge forming the widest part. Lateral margins broadly rounded to gently convex and sloping toward the middle. Anterior margin nearly straight to slightly emarginate. Anterior commissure moderately uniplicate. Surface finely costellate, 3 to 4 costellae occupying 1 mm. at the front margin.

Pedicle valve unevenly convex in lateral profile with the anterior half moderately convex but the posterior half flattened. Anterior profile broadly convex and with the median portion slightly depressed. Beak small, barely perceptible on the posterior margin. Umbo sulcate, the sulcus extending from the beak to the anterior margin, deepening and widening anteriorly but not of great depth at its deepest anterior part. Flanks with long, moderately steep slopes facing the cardinal

extremities and with the anterolateral portions gently swollen. Interarea short, apsacline.

Brachial valve very gently concave in lateral and anterior profiles. Umbonal and median regions nearly flat. Anteromedian portion gently elevated in a low fold corresponding to the shallow pedicle sulcus. Lateral margins slightly reflected toward the brachial valve but the main portion of the flanks gently concave; portion of flanks adjacent to folded area somewhat depressed along the margin.

Interior of brachial valve, cardinal process trilobed, moderately large; median ridge long, low, extending nearly to front margin; lateral ridges thick; sockets deep; brachial processes obsolete.

Measurements in mm.—Holotype, length 15.0, midwidth 21.9, hinge width (based on half measure of 11.4) 22.8, thickness 4.2.

Types.—Holotype, U.S.N.M. No. 115499; figured paratypes, U.S.N.M. Nos. 115500, 115501; unfigured paratype, U.S.N.M. No. 115502.

Horizon and locality.—*Spiriferellina* zone, loc. 806d, 806f.

Discussion.—This species is fairly common in the upper beds of the Monos formation but it is difficult to prepare good specimens. It is the largest of the chonetids so far found in the vicinity of El Antimonio and for this reason is quite easy to recognize. It is suggestive of *C. deliciasensis* King but differs in having a well-defined fold and sulcus. *Chonetes phosphoriensis* Branson is a related species but appears to have been somewhat smaller in size and with a deeper sulcus and more extended cardinal extremities. *Chonetes kaibabensis* McKee is a comparable form but differs in having a more subdued sulcus on the pedicle valve. Poor preservation of the Kaibab species prevents a more detailed comparison of the two species which agree in proportions.

HETERALOSIA MEXICANA Cooper, new species

Plate 7A, figures 1-3

Shell of about the usual size for the genus, concavo-convex, slightly wider than long with a subcircular to subelliptical outline; hinge narrow. Anterior commissure not folded. Surface of pedicle valve ornamented by short, thick, oblique, hollow spines lying at a low angle to the surface or recumbent on the surface. Brachial valve without spines.

Pedicle valve forming a low, unsymmetrical cone with the truncated apex at the posterior end; lateral profile moderately convex with the greatest convexity in the posterior half; anterior with about the same convexity as the lateral profile. Umbonal and beak region represented by a small depressed and rough area that constitutes the cicatrix of

attachment. Median region swollen and with moderately steep slopes to the lateral and anterior margins. Interarea short, flat and narrow; apsacline.

Brachial valve moderately concave in lateral and anterior profiles. Umbonal region slightly swollen and convex, descending to the concave median area. Sides slightly elevated toward the brachial valve to fit snugly into the pedicle valve.

Measurements in mm.—Holotype, length 13.3, width 16.5, hinge width 7.5, thickness at middle 3.3.

Holotype.—U.S.N.M. No. 115587.

Horizon and locality.—*Spiriferellina* zone, loc. 806f.

Discussion.—The only comparable described species is *Heteralosia hystricula* Girty, formerly referred to *Strophalosia* and occuring in the Word formation of the Glass Mountains of Texas. This species does not grow to the size of the Mexican species and is usually much less expanded and deeper. Furthermore the attachment scar of the Texas species is usually larger than that of *H. mexicana.*

CANCRINELLA PHOSPHATICA (Girty)

Plate 7B, figures 4-11

Productus phosphaticus GIRTY, U. S. Geol. Surv. Bull. 436, p. 29, pl. 2, figs. 7-9, 1910.

Linoproductus (*Cancrinella*) *phosphaticus* (Girty) R. E. KING, Univ. Texas Bull. 3042, p. 77, pl. 17, figs. 6-7, 1930.

Shell moderately large for the genus, subovate in outline, auriculate with the hinge about equaling the greatest width. Cardinal extremities approximately a right angle. Deeply concavo-convex. Lateral margins gently rounded; anterior margin somewhat narrowly rounded. Length and width subequal to longer than wide. Surface multicostellate, with about 8 to 10 costellae to 5 mm. at the front margin of an adult. Concentric wrinkles numerous, narrow, not strongly pronounced on the body of the shell but much concentrated on the ears. Spines long and slender, scattered irregularly over body of shell but concentrated on the ears. Surface spine bases elongate posterior to the point of elevation of the spine; spines slightly elevated above surface and attached at a very low angle.

Pedicle valve strongly convex in lateral profile with the greatest convexity in the posterior half; anterior profile more broadly rounded than the lateral profile. Umbonal region swollen and tumid, the swelling continuing to the median region but becoming less anteriorly. Umbonal slopes rounded and steep. Lateral slopes convex but only

moderately steep. Anterior slope long and gentle. Beak narrow and small, arched over the umbo of the brachial valve.

Brachial valve deeply concave in both profiles and closely fitting the inner concavity of the pedicle valve. Umbonal region deeply concave; beak little developed. Surface without spines.

Measurements in mm.—Hypotype, U.S.N.M. No. 115573a, length (crest of umbo to front margin) 30.0, midwidth 27.0?, hinge width ?, thickness ?, surface measure of pedicle valve 40.0. Figured specimen, U.S.N.M. No. 115572a, length (crest of umbo to front margin) 28.5, midwidth (based on half measure of 11.4?) 22.8?, hinge width (based on half measure of 13.6) 27.2, thickness ca. 5.0, surface measure of pedicle valve, 50.0?

Hypotypes.—U.S.N.M. Nos. 115572a, b, 115573a, b, I.G.M.

Horizon and locality.—Fairly common in *Leiorhynchoidea-Cancrinella* zone, loc. 806i.

Discussion.—This species is most readily recognized by its general similarity of habit to *Linoproductus* but it differs in possessing more spines and narrow, concentric wrinkles on the body of the shell. The wrinkles are concentrated at the ears.

This genus occurs in Pennsylvanian and Permian rocks in other parts of North America as well as in Europe and Asia. In North America its species are usually not of common occurrence but are found sparingly. In Mexico a closely related species, *Cancrinella rugosa* Cloud, occurs in bed 17 of the Difunta section and beds 5 to 7 of the Malascachas section, both in the Permian area of Las Delicias, Coahuila. The Coahuila species differs from *C. phosphatica* in having stronger and more distantly spaced costellae, 6 or 7 in 5 mm. compared to 8 to 10 costellae in the same distance in the Monos Hills specimens.

Cancrinella phosphatica is known in the United States from the phosphate beds of the Park City formation of Idaho near Montpelier. King (1930, p. 77) figures this species from the upper part of the Word formation, Glass Mountains, Tex. In Europe and Asia the most closely related species is *Cancrinella cancriniformis* Tschernyschew.

ANIDANTHUS ALATUS Cooper, new species

Plate 7C, figures 12-26

Small, wider than long with the hinge forming the widest part. Outline elliptical to subrectangular. Cardinal extremities alate. Lateral margins sloping medianly; anterior margin broadly rounded. Anterior commissure slightly uniplicate. Surface costellate, costellae narrowly rounded, subequal in size, separated by striae that are much narrower

than the costellae. Brachial valve strongly plaited by growth layers. About 2 to 3 costellae occupy the space of 1 mm. at the front margin of an adult pedicle valve. Spines on the body of pedicle valve scattered, not numerous and arising from the costellae at a low angle. Hinge spines long, slender, at least 5 on each side of the beak.

Pedicle valve very strongly and unevenly convex in lateral profile, the greatest convexity occurring in the umbonal region. Anterior profile strongly and broadly convex with long lateral slopes and a sulcate median region. Umbo swollen, entirely visible in the brachial view of a complete specimen. Sulcus narowly U-shaped, shallow to moderately deep, originating 7 to 10 mm. anterior to the beak and extending to the front margin. Flanks bounding sulcus narowly rounded and with steep lateral slopes. Cardinal extremities narrowly convex and extended into prominent alae.

Brachial valve moderately deeply concave in lateral and anterior profiles, the greatest concavity located in the umbonal region. Median area flatly concave, rising posterolaterally and anterolaterally to the margins. Anterior margin forming a rim around the inner concavity. Cardinal extremities concave, somewhat elevated above the valve and not sharing in the plaited character of the brachial valve. Costellae on alae fine, radial, uninterrupted by growth lines and often overlying the plaits of the main body of the valve.

Interior of pedicle valve with heavy umbonal callus; median ridge corresponding to and formed by the infolding of the valve caused by the sulcus. Diductor scars large and flabellate; adductor impressions large, confined to the median ridge. Brachial interior with low cardinal process and short, thick median ridge.

Measurements in mm.—Holotype, length 19.6 plus, midwidth 22.5, hinge width 27.8, surface length of pedicle valve ca. 33.0, thickness at center 5.6; paratype (U.S.N.M. No. 115590a), length 14.8, midwidth 19.9, hinge width (based on half measure of 13.0) 26.0, surface length of pedicle valve ca. 27.0, thickness at middle 5.0.

Types.—Holotype, U.S.N.M. No. 115471; figured paratypes U.S.N.M. Nos. 115572a, b, 115590a; unfigured paratype, U.S.N.M. No. 115590b, I.G.M

Horizon and locality.—Abundant in the *Anidanthus* zone, loc. 806m, 806n, 806-o.

Discussion.—This species is characterized by its small size, the strong convexity, peculiar development of the alae and the plaited nature of the brachial valve. At least three other species are known which are similar to *A. alatus*. The phosphate beds of the Park City

formation of Idaho have yielded *A. eucharis* (Girty) which possesses a plaited brachial valve but is a much smaller shell and one that is not so strongly alate. *Anidanthus waagenianus* (Girty) from the Capitan limestone is similar but much smaller and more compressed. *Anidanthus waagenianus* as figured by King seems to consist of two species, one from the Leonard and one from the Word formation and neither of them conspecific with Girty's species. Neither the Leonard nor the Word species is like *A. alatus*. The Word specimens are even more alate than the Mexican species while the Leonard specimens are narrower and smaller.

DICTYOCLOSTUS DEPRESSUS Cooper, new species

Plate 8, figures 1-10; plate 9B, figures 8-13; plate 10A, figures 1-4

Shell fairly large for the genus, length and width subequal, strongly geniculated and with moderately long trail, about 25 mm. long in an adult. Surface marked by fine costellae that are reticulated over the posterior nongeniculated surface by concentric undulations of about the same size as the costae. Radial costae not increasing greatly in size anteriorly and quite uniform in size over the anterior geniculation surface. No spines preserved on the pedicle valve. Visceral chamber moderately large.

Pedicle valve strongly geniculated in lateral profile, the geniculation taking place 30 to 40 mm. (surface measure) anterior to the beak. Geniculation taking place in a narrow curve causing umbonal and trail surfaces to be approximately parallel in adults. Umbonal region swollen, its sides forming an angle of about 95° with the beak. Sides of umbo descending steeply to the cardinal region. Beak protruding slightly posterior to the posterior margin. Sulcus strong and deep for the genus, originating on the umbo 5 to 10 mm. anterior to the beak and extending to the anterior margin. Sulcus narrowly U-shaped in section, widening slightly and becoming somewhat shallower toward the anterior margin. Flanks bounding sulcus swollen in the visceral area but well rounded and with very steep slopes in the anterior part. Ears prominent, moderately well rounded.

Brachial valve gently concave in visceral area, strongly geniculated at an angle of about 90° anteriorly. Umbonal region concave for a distance of about 5 mm. from the beak but becoming elevated into a low narrow fold anteriorly. Areas bounding fold flat to gently concave. Long slender spines extend posteriorly and medially from geniculated portion.

Interior of pedicle valve with broadly flabellate diductor impressions, adductor scars located on the strong median ridge.

Interior of brachial valve with erect cardinal process having a long shaft and lobate myophore. Median crest of myophore strong, margined by deep muscle pits. Adductor area cordate in outline, the scars dendritic. Median ridge anterior to the adductor area slender and extending to the anterior margin. Brachial impressions located near the outer margins. Lateral ridge high and slender.

Measurements in mm.—Holotype, length 49.6, surface length, beak to anterior margin 96.0 plus, hinge width (based on half measure of 26.4) 52.8; paratype (U.S.N.M. No. 115482), length 44.5, surface length 80+, width at middle 39, hinge width (based on incomplete half measure of 22.5) 45+.

Types.—Holotype, U.S.N.M. No. 115467; figured paratypes, U.S.N.M. Nos. 115561, 115468, 115482, 115483a, b, 115490a, I.G.M.; unfigured paratype, U.S.N.M. No. 115469a.

Horizon and locality.—*Dictyoclostus* zone, loc. 806k, 806k′, 806-l, 806m′, 806x, 806z: *Anidanthus* zone, loc. 806m, 806n, 806-o; highest Permian, loc. 806t.

Discussion.—This species is characterized by its depressed form, the surface of the pedicle valve is essentially parallel to the surface of the trail. It is suggestive of *D. ivesi* (Newberry) and more particularly of *D. bassi* McKee. From the first it differs in its larger size, deeper sulcus, narrower umbo and more strongly geniculate and depressed form. *Dictyoclostus depressus* differs from *D. bassi* in its generally smaller size although some specimens approach the surface measure of the pedicle valve of the Kaibab species. The sulcus of the pedicle valve of *D. bassi* is never so deep and narrow as that of the Mexican species. The umbo of the pedicle valve of *D. bassi* is swollen and the sulcus originates 20 to 25 mm. anterior to the beak whereas in *D. depressus* the sulcus originates only a short distance, 5 to 10 mm. anterior to the beak. The lateral profile of *D. bassi* is much less curved than that of *D. depressus,* the former presenting a much more massive appearance than that of the Mexican species.

DICTYOCLOSTUS DEPRESSUS subspecies

Plate 10B, figures 5-8

Scattered specimens of a *Dictyoclostus* related to *D. depressus* occur in the uppermost beds of the *Spiriferellina* zone, locality 806g. Three specimens only were collected but they have important differences from *D. depressus.* The sulcus of the pedicle valve is much deeper and consequently the brachial fold is also stronger than that seen on any of the specimens found lower in the section. Furthermore, the reticu-

lation of the posterior is stronger than that of *D. depressus* and the valves are not so depressed.

Figured specimen.—U.S.N.M. No. 115484.

MARGINIFERA, species 1

Plate 6A, figures 1-7

Shell small, transversely subrectangular in outline; auriculate and with the hinge forming the widest part. Deeply concavo-convex. Sides sloping gently toward the middle; anterolateral extremities narrowly rounded; anterior margin with median reentrant. Surface paucicostate, costae subdued, rounded, confined to flanks and anterior slope. Spines few, large, scattered, located chiefly on anterior slope and two large ones overhanging auricles at base of umbonal slope; spines occasional on posterior margin of ears.

Pedicle valve strongly convex in lateral profile, with greatest convexity located at place of geniculation. Anterior profile bilobate. Umbonal region moderately to strongly swollen with steep umbonal slopes. Sulcus originating about 5 mm. anterior to the beak, narrow but deep and extending anteriorly to the front margin. Flanks bounding sulcus narrowly rounded and with steep lateral slopes. Valves geniculated at an angle of nearly 60° at a distance of about 10 mm. anterior to the beak. Geniculated area broadly rounded, the rounding continuing to the moderately long trail. Beak small, incurved, overhanging the brachial umbo slightly. Ears small, gently rounded and slightly less than a right angle.

Brachial valve concave with margins deflected toward the brachial valve to form a deep lid fitting closely into the pedicle valve; visceral chamber moderately deep. Umbonal and median regions concave nearly to the front and lateral margins where the valve is deflected brachially at a high angle. Median fold short, low, defined only on the anterior deflected marginal region. Ears flattened, small.

Interior features not well preserved; brachial ridges medianly located; submarginal spines few, long, scattered; inner margin small.

Measurements in mm.—Figured specimen, U.S.N.M. No. 115562a, length (umbonal crest to front margin) 13.4, midwidth 16.1, hinge width (based on half measure of 9.4) 18.8?, thickness at middle 3.8, surface of pedicle valve 24.0.

Specimens.—Figured specimens, U.S.N.M. Nos. 115562a, 115563a; unfigured specimens, U.S.N.M. No. 115562b, I.G.M.

Horizon and locality.—*Dictyoclostus* zone, loc. 806k, 806k′, 806-l.

Discussion.—This species has some similarity to the *Marginifera,*

species 2, of the *Composita* zone which may be related more or less closely to *M. popei* (Shumard). It is, however, a much smaller species, more convex, somewhat more costellate, and is confined to the *Dictyoclostus* zone so far as our present knowledge goes. The few specimens collected are poorly preserved, thus making the material inadequate for specific description or accurate identification.

MARGINIFERA, species 2

Plate 6C, figures 13-22

Shell moderately large for the genus, transversely subrectangular in outline; deeply concavo-convex; auriculate, hinge forming widest part. Lateral margins slightly concave just anterior to the ears, gently convex on sides; anterolateral extremities narrowly rounded, anterior margin nearly straight to slightly indented at the middle. Anterior commissure uniplicate. Surface paucicostate and spinose; costae subdued, irregular, rounded, preserved chiefly on the lateral and anterior slopes. Spines large, scattered, occurring at the base of the umbonal slope.

Pedicle valve narrowly convex in lateral profile and bilobed in anterior profile. Visceral region short, swollen. Umbo swollen and with very steep lateral slopes. Sulcus originating 5 mm. anterior to the beak, deep, broadly U-shaped, with moderately sloping sides. Flanks bounding sulcus narrowly rounded, with swollen and steep slopes. Beak small, overhanging the brachial umbo. Ears small, not strongly rounded. Geniculation occurring slightly more than 10 mm. anterior to the beak.

Brachial valve concave in both profiles and with the sides deflected toward the brachial valve to surround the deep inner concavity. Median region deeply concave but floor of concavity somewhat flattened. Median fold broadly carinate, short, originating at or near the middle.

Brachial interior with median septum extending anterior to the middle; brachial markings widely spaced; adductor scars prominent; submarginal ridge not strongly elevated but represented by considerable thickening of the shell.

Measurements in mm.—Figured specimen, U.S.N.M. No. 115564b, length (crest of umbo to front margin) 17.6, midwidth 22.1, hinge width 23.0 plus, thickness ?, surface measure of pedicle valve 30.0.

Figured specimens.—U.S.N.M. Nos. 115564a, b, I.G.M.

Horizon and locality.—*Composita* zone, loc. 806c, 806h, 806r; *Spiriferellina* zone, loc. 806b.

Discussion.—The specimens on which the above description is based

are very poorly preserved and do not permit accurate comparison with other known species. They suggest *Marginifera popei* (Shumard) which is abundant in the Glass, Guadalupe, and Delaware Mountains of Texas. This species was identified by McKee from the Kaibab limestone of the Grand Canyon, Ariz.

LIOSOTELLA Cooper, new genus

Shell, based on known species, ranging in size from small to moderately large; strongly concavo-convex; hinge line wider than the shell at the middle; cardinal extremities auriculate. Anterior commissure narrowly uniplicate; pedicle sulcus shallow to deep; brachial fold usually low and obscure. Surface costate; costae spinose. Umbonal and juvenile parts of the valves smooth to indistinctly costate and with a few scattered small spines. Costae on anterior and body strong, bearing scattered erect strong spines. A row of strong spines appears on the steep umbonal slopes and overhangs the ears which are smooth.

Pedicle interior with adductor muscles located on a strong median elevation just posterior to the middle; diductor impressions large and flabellate. Concave auricles walled off from visceral region by a low oblique ridge. Brachial interior with stout, short cardinal process having a trilobed myophore. Median ridge low, extending slightly anterior to the middle; marginal ridges not strongly developed; brachial impressions prominent, occupying the middle; inner surface more or less deeply pitted.

Genotype.—*Liosotella rugosa* Cooper, new species.

Discussion.—This genus is recognizable by its external form and ornamentation suggesting large specimens of *Avonia* or members of the *Dictyoclostus occidentalis* group of *Dictyoclostus.* Only a casual inspection is necessary to distinguish *Liosotella* from *Avonia* because of differences in details of the ornamentation but more particularly in the arrangement of the spines and in the interior. The spines of *Avonia,* at least as that genus is identified in the Permian rocks of North America, are scattered irregularly over the surface particularly in the sparsely plicated anterior region. *Avonia* is not provided with prominent ears separated from the visceral chamber by a well-defined partition. Inside the brachial valve of *Avonia* the brachial ridges diverge from the hinge line, a situation entirely different in the new genus under discussion.

Liosotella differs from *Dictyoclostus* in at least two respects. One of the most important differences is the complete lack of reticulate ornamentation on the posterior portions of both valves. Furthermore, the ears of *Dictyoclostus* usually are very spinose.

LIOSOTELLA ANGUSTATA Cooper, new species

Plate 11B, figures 5-10

Shell of about medium size for the genus, subrectangular in outline with the width slightly greater than the length. Auriculate, but with the hinge only slightly wider than the midwidth. Deeply concavo-convex; visceral area shallow. Anterior commissure slightly uniplicate. Surface marked by irregular, uneven costae, rounded and confined to the flanks and the anterior slope. Spines scattered and small on anterior slope but large and stout in a curved row at the base of the umbonal slopes.

Pedicle valve fairly evenly convex in lateral profile and with the maximum curvature in the median region. Anterior profile somewhat quadrate but with the pedicle valve depressed in the middle. Umbonal region swollen; umbonal slopes steep. Median sulcus originating just anterior to the umbo and extending to the front margin; sulcus shallow and broad, forming a wide shallow trough. Flanks swollen and rounded, with nearly vertical slopes. Ears small, gently rounded; beak small, incurved.

Brachial valve deepest in the median region with steep lateral slopes but a somewhat less steep anterior slope. Fold originating in anterior half, low, poorly developed. Cardinal extremities flattened.

Interior unknown.

Measurements in mm.—Holotype, length (crest of umbo to anterior margin) 21.8, midwidth 24.2, hinge width (based on half measure of 13.7) 27.4?, thickness at middle 7.2, surface measure of pedicle valve 40.0; paratype, length (crest of umbo to anterior margin) 20.6, midwidth 22.3, hinge width 24.0 plus, thickness ?, surface measure of pedicle valve 37.0.

Types.—Holotype, U.S.N.M. No. 115465; figured paratype, U.S.N.M. No. 115466.

Horizon and locality—Rare in the *Anidanthus* zone, loc. 806n, 806-o.

Discussion.—This is the smallest of the species occurring in the Monos Hills and can be distinguished from *L. rugosa,* with which it occurs, by its costation being confined to the anterior portion of the flanks and anterior slope.

LIOSOTELLA RUGOSA Cooper, new species

Plate 10C, figure 9; plate 11C, figures 11-18

Shell moderately large, subrectangular to subquadrate in outline, deeply concavo-convex; auriculate with the hinge forming the widest part; lateral margins gently convex; anterolateral extremities narrowly

convex; front margin gently curved. Umbonal region smooth or with scattered small spines; anterior two-thirds strongly costate, costae numbering 2 or 3 in 5 mm. at the front margin. Costae bearing scattered erect spines; large spines also developed in a curved row of 6 spines diminishing in size posteriorly near the base of the umbonal slope and overhanging the ears, which are smooth. Umbonal and body spines slender.

Pedicle valve strongly convex in lateral profile and with the greatest convexity in the median portion. Anterior profile somewhat rectangular with a median depression representing the sulcus, and with nearly vertical sides. Umbo moderately swollen; sulcus and costation originating 5 to 7 mm. anterior to the beak; sulcus narrow, shallow, and extending to the anterior margin. Umbonal slopes steep; flanks bounding sulcus narrowly rounded and with nearly vertical sides. Ears rectangular; narrowly rounded in section. Beak small, strongly incurved and overhanging the umbo of the brachial valve.

Brachial valve deeply concave in lateral and anterior profiles; umbonal region deeply concave, bounded posterolaterally by flattened areas corresponding to the auricles. Median ridge low, subangular, extending anteriorly to the front margin from a point about 5 to 7 mm. from the beak. Flanks deeply concave; inner concavity bounded by the anterior margins strongly directed toward the brachial valve.

Interior, brachial valve with small delicate cardinal process having small trilobed myophore and short shaft.

Measurements in mm.—Holotype, length (crest of umbo to anterior margin) 26.0, midwidth 31.7, hinge width, 35.7, thickness 8.2, surface measure of pedicle valve 52.0; paratype (U.S.N.M. 115459a): length (crest of umbo to front margin) 28.2, midwidth 29.6, hinge width (based on half measure of 17.8) 35.6, thickness 5.8, surface measure of pedicle valve 50.0.

Types.—Holotype, U.S.N.M. 115458; figured paratypes, U.S.N.M. 115459a, I.G.M.; unfigured paratype, U.S.N.M. No. 115459b.

Horizon and locality.—Rare in *Composita* zone, loc. 806c, 806h, 806r, 806v; *Dictyoclostus* zone, loc. 806k′, 806x; *Leiorhynchoidea-Cancrinella* zone, loc. 806i; *Anidanthus* zone, loc. 806m, 806n; *Spiriferellina* zone, loc. 806g.

Discussion.—This species is characterized by its prominent median sulcus, fairly strong fold on the brachial valve, and prominent anterior costation. The species differs from strongly marked members of *L. subrugosa,* which occur in higher strata, in the greater prominence of the sulcus and fold, a less strongly arched umbo and somewhat more prominent costation. It is possible that specimens referred to *L. sub-*

rugosa occurring in the *Composita* and *Spiriferellina* zones should be referred to *L. rugosa* and that the subdued costation of the latter, as well as the apparently more arched umbo, are features of poor preservation. Unfortunately sufficient specimens are not available in the collections made to settle this point.

LIOSOTELLA SUBRUGOSA Cooper, new species

Plate 11A, figures 1-4; plate 12B, figures 9-17

Shell moderately large, transversely subrectangular in outline, auriculate, with the hinge forming the widest part; deeply concavo-convex. Lateral margins gently rounded; anterolateral extremities somewhat narrowly rounded; anterior margin nearly straight, faintly uniplicate. Umbonal region nearly smooth; umbonal slopes, anterior half and flanks marked by low, rounded, irregular costae. Spines few, erect, scattered on surface of venter and in a row of 6 large spines located along the base of the umbonal slope and overhanging the auricles.

Pedicle valve strongly convex in lateral profile with the greatest convexity located in the median region. Anterior profile strongly arched, with nearly vertical sides and slightly bilobate crest. Umbonal region moderately strongly swollen; beak small and overhanging brachial umbo. Sulcus originating 10 to 15 mm. anterior to the beak, shallow with a narrow median furrow and broadly sloping sides, extending to the front margin. Flanks tumid with steep sides. Anterior slope convex, very steep. Ears large, narrowly rounded on the extremity and in section.

Brachial valve deeply concave in lateral and anterior profiles; umbo forming a concavity within the main visceral region; concavity deepest in the median region. Fold originating near the middle, low and not strongly defined. Sides forming a steep rim around the central concavity.

Interior of pedicle valve with umbonal cavity thickened by callus; diductor impressions large, located near the middle of the valve; adductor field large, elongated, elevated on a low, wide ridge extending nearly to the middle. Interior of brachial valve with short, stout-shafted cardinal process having a trilobate myophore. Median ridge low. Adductor scars crenulated, located posterior to the brachial ridges which occupy the middle region. Marginal ridges low and indistinct.

Measurements in mm.—Holotype, length (crest of umbo to front margin) 29.4, midwidth 32.5, hinge width 34.0 plus; thickness at middle 12.5, surface measure of pedicle valve 58.0.

Types.—Holotype, U.S.N.M. No. 115460; figured paratypes, U.S.N.M. Nos. 115461-115463, I.G.M.

Horizon and locality.—*Spiriferellina* zone, loc. 806b, 806d, 806d′, 806f, 806g, 806h², 806s, 806w.

Discussion.—This species as defined is characterized by its strongly arched umbo, its subdued ornamentation, sulcus on pedicle valve shallow, faint fold on brachial valve and large thick cardinal process. In all these respects it differs from the well-marked specimens occurring in the *Anidanthus* zone. The distinctions named, as already pointed out, are not clearly marked in all specimens but the end members are quite distinctive. It is possible that a large collection of better-preserved specimens will show *L. rugosa* and *L. subrugosa* to be one species. Collecting of these fossils is very difficult and it is doubtful if better-preserved material is to be found in the Monos Hills. Consequently the question cannot now be answered.

LIOSOTELLA MAGNIRUGOSA Cooper, new species

Plate 12A, figures 1-8

Shell large, subquadrate in outline; strongly auriculate and with the hinge forming the greatest shell width. Sides sloping gently medially; anterolateral extremities narrowly rounded; anterior margin indented in the median region. Anterior commissure gently uniplicate. Surface paucicostate, the flanks, venter, and anterior slopes marked by strong, narrowly rounded costae, about 20 in number, and a few of the larger ones bifurcating near the anterior margin. Spines large, scattered on the anterior slope and an oblique row of 3 or more located at the base of the umbonal slope. Umbonal region without ornament.

Pedicle valve strongly convex in lateral profile and with the greatest convexity located in the median part. Anterior profile slightly bilobate. Umbonal region swollen, tapering to a small beak that overhangs the brachial umbo. Umbonal slopes rounded, steep. Auricles large, well rounded. Median sulcus originating about 15 mm. anterior to the beak, extending to the front margin, broad and shallow, occupying about one-third the width at the front margin. Flanks narrowly rounded, with vertical sides to the lateral margins. Anterior slope very steep.

Brachial valve most deeply concave in the median region and with the umbo strongly concave. Anterior margins strongly deflected brachially and with steep inner margins. Fold low, broad, not strongly developed; ears strongly concave.

Details of the interior few; cardinal process with small myophore; brachial ridges strong, widely spaced.

Measurements in mm.—Holotype, length (crest of umbo to anterior margin) 29.8, midwidth 29.6, hinge width 41.0 (restored), thickness

at middle 9.6, surface measure of pedicle valve, beak to anterior margin 51.0, depth 23.0; paratype (I.G.M.): length (crest of umbo to anterior margin) 25.7, midwidth 25.5, hinge width 24.0 plus, thickness 8.5, surface measure of pedicle valve 46.5, depth 15.6.

Types.—Holotype, U.S.N.M. No. 115464; figured paratype, I.G.M.

Horizon and locality.—*Leiorhynchoidea-Cancrinella* zone, loc. 806i.

Discussion.—This species is not uncommon in the *Cancrinella* zone but specimens are difficult to prepare. Consequently a few specimens only are available for study. As revealed by these specimens the species is characterized by its large size, strong ears, swollen umbo, broad, shallow sulcus and, consequently, broad and low fold on the brachial valve and finally by the strong costae. In comparison to *L. rugosa* the fold and sulcus of *L. magnirugosa* are less pronounced and much broader, the costae are much stronger, the umbo is somewhat more swollen and the ears more extended.

MUIRWOODIA species

Plate 9A, figures 1-7

Shell large for the genus, strongly concavo-convex, subquadrate to subrectangular in outline; auriculate, with the hinge forming the widest part. Anterior commissure narrowly uniplicate. Lateral margins concave anterior to the auricles, narrowly rounded at the anterolateral extremities and emarginate at anterior margin. Surface multicostellate, costellae narrow, rounded, separated by striae somewhat narrower than the costellae. Costellae numbering about 10 in 5 mm. on the body of the shell and along the front margin. Spines not preserved.

Pedicle valve very unevenly convex in lateral profile with the visceral area gently convex. Anterior profile bilobate. Umbonal and visceral regions moderately swollen; median sulcus originating 3 to 5 mm. anterior to the beak, narrow, deep, widening and deepening to the anterior margin. Flanks on visceral area moderately swollen and with short concave slopes to the cardinal extremities. Geniculation occurring 20 mm. anterior to the beak; geniculated portion narrowly rounded with tumid areas bounding the median sulcus. Trail long, deeply sulcate and with well-rounded flanks bordering the sulcus. Umbonal surface and trail surface approximately parallel. Lateral slopes steep. Beak small, protruding slightly posterior to the posterior margin.

Brachial valve poorly exposed in four available specimens but indicating a short and shallow visceral area and a sharply geniculated portion closely fitted to the trail of the pedicle valve. A sharp but low fold is indicated by the deep sulcus.

Measurements in mm.—Figured specimen, length (crest of umbo to anterior margin) 27.6, midwidth 41.0, hinge width 47.0 plus (auricles not preserved), thickness ?, surface measure of pedicle valve 62.0.

Figured specimens.—U.S.N.M. No. 115568, I.G.M.

Horizon and locality.—*Dictyoclostus* zone, loc. 806k, 806-l. *Leiorhynchoidea-Cancrinella* zone, loc. 806i.

Discussion.—The specimens figured and described herein probably represent a new species of this interesting genus but are too poor to describe as new. This genus has hitherto not been reported on this continent but it is represented by several species. *Productus geniculatus* Girty from the Park City formation and *P. multistriatus* Meek of the Phosphoria formation are representatives. *Dictyoclostus deminutivus* Cloud from the Permian of Coahuila, according to description and figures, belongs to the genus *Muirwoodia.*

The specimens from Monos Hills are most similar to *Muirwoodia multistriata* (Meek) but differ in having a much less inflated umbonal and visceral disc region, a stronger, deeper, and more angular sulcus on the pedicle valve and a much stronger degree of geniculation.

WAAGENOCONCHA MONTPELIERENSIS (Girty)

Plate 13, figures 1-14

Productus montpelierensis Girty, U. S. Geol. Surv. Bull. 436, p. 30, pl. 2, figs. 5,6, 1910; U. S. Geol. Surv. Prof. Pap. 152, p. 80, pl. 28, figs. 12,13, 1927.

Pustula montpelierensis (Girty) Branson, Univ. Missouri Studies Quart., vol. 5, No. 2, p. 32, 1930.

Shell large, variable, slightly wider than long in the young, with length and width subequal in the young adult and with the length forming the greatest dimension in old specimens. Hinge narrower than the greatest width which is located at or anterior to the middle. Cardinal extremities rounded. Nearly planoconvex in section. Surface marked by fine, elongated pustules which, in life, bore very slender spines; spine bases arranged in quincunx, the arrangement generally clearer on the brachial than on the pedicle valve. Growth undulations common on the surfaces of old specimens.

Pedicle valve strongly convex in lateral profile and with the maximum convexity located in the umbonal region. Anterior profile forming two somewhat narrowly rounded lobes separated by a shallow sulcus. Umbonal region swollen and protruding considerably posterior to the posterior margin. Beak small, strongly incurved and overhanging the hinge and a small portion of the brachial umbo. Sulcus origi-

nating just anterior to the umbo and about 7 to 10 mm. anterior to the beak. Sulcus strong in young shells, with a broadly V-shaped section, anteriorly becoming somewhat less deep in adults but present from umbo to front margin at all ages. Flanks bounding sulcus with steep to moderately steep slopes into the sulcus, with narrowly rounded and inflated crests and steep to nearly vertical slopes to the lateral margins.

Brachial valve nearly flat in the posterior two-thirds but strongly geniculated in a brachial direction in the old adults. Umbonal region concave for about 5 mm., after which a low, broad fold originates that extends to the anterior margin. Low, oblique folds bound the concave umbonal region and extend anterolaterally about 10 mm., after which they disappear. Cardinal extremities gently sulcate between the cardinal margin and the oblique folds referred to above. Lateral and anterior margins of adults geniculated brachially, about 20 to 25 mm. anterior to the beak, the geniculation extending for a considerable distance in old adults.

Interior of pedicle valve with broadly flabellate diductors as usual in the Productacea. Brachial valve with large cardinal process having a long shaft and trilobate myophore strongly recurved into the umbonal chamber of the pedicle valve. Median ridge slender, extending for at least two-thirds the length of the valve. Place of geniculation marked by a curved row of strong but short spines.

Measurements in mm.—Hypotypes: (U.S.N.M. No. 115515), length (crest of umbo to front margin) 26.9, midwidth 30.5, hinge width ?, thickness at middle 12.3; (U.S.N.M. No. 115512), length (umbo to front margin) 33.5, midwidth 35.0, hinge width 25.0?, thickness at middle 9.0 (somewhat crushed); (U.S.N.M. No. 115511), length (crest of umbo to front margin) 42.6, midwidth (based on half measure of 23.0) 46.0, hinge width 33.5, thickness at middle 14.2; (U.S.N.M. No. 115510), length (crest of umbo to front margin) 53.0, midwidth 42.0 hinge width 28.0?, thickness at middle 22.3.

Hypotypes.—U.S.N.M. Nos. 115510-115513, 115515.

Horizon and locality.—*Anidanthus* zone loc. 806n, 806-o; *Dictyoclostus* zone, loc. 806k, 806k′, 806-l, 806p, 806z; *Leiorhynchoidea-Cancrinella* zone, loc. 806i; *Composita* zone, loc. 806h; *Spiriferellina* zone, loc. 806b, 806d, 806d′, 806f, 806g.

Discussion.—*Waagenoconcha montpelierensis*, as interpreted herein, is more broadly viewed than hitherto. Girty's type specimen is that of a small shell but may be a young specimen. Young individuals of the Mexican specimens conform almost precisely to Girty's description and figures. These specimens, however, are clearly the young of

larger ones. In general the geniculation at the front of the valves takes place about 20 mm. anterior to the beak of the brachial valve but a few specimens geniculate at a slightly earlier stage. This may be a premature assumption of adult characters or these specimens may represent another species. Enough specimens to prove this point are not available for study. A fairly complete series of stages is present to indicate that young having the characters of *W. montpelierensis* grow to a large size, a size larger than hitherto suspected.

LEIORHYNCHOIDEA CLOUDI Cooper, new species

Plate 14C, figures 16-31

Pugnax weeksi nobilis Girty, U. S. Geol. Surv. Bull. 436, p. 32, pl. 3, fig. 7 (not 5,6), 1910. R. E. King, Univ. Texas Bull. 3042, p. 105, pl. 33, figs. 9-11, 1930.

Shell large, suboval in outline, with length and maximum width nearly equal. Posterior margins gently convex, anterolateral extremities somewhat narrowly rounded; anterior margin broadly convex. Anterior commissure broadly uniplicate. Surface costate, costae broad and subangular, 2 costae occupying the sulcus, 3 marking the fold, and 4 to 5 present on the flanks.

Pedicle valve with gentle curvature in lateral profile, the greatest curvature located in the umbonal region; anterior profile very broadly and gently convex. Umbonal region swollen, smooth; costation originating 6 to 8 mm. anterior to the beak. Sulcus originating at about the middle, shallow and broad. Flanks with long anteromedian extremities that are moderately elevated. Flanks gently convex posteriorly but somewhat flattened anteriorly. Beak strongly incurved and closely pressed onto the brachial umbo; foramen minute, permesothyrid. Beak ridges elongate but false areas very narrow. Deltidial plates conjunct but showing line of junction, flat to concave.

Brachial valve in lateral profile gently convex with the greatest convexity in the umbonal region; anterior profile very broadly convex but more convex and deeper than the pedicle valve. Umbonal region gently swollen, smooth. Fold originating at about the middle, flattened and not rising above the flanks except in the anterior region. Flanks gently convex and with long anterolateral extensions to meet the reentrant formed by the anteromedian elevation of the flank of the pedicle valve. Beak incurved under, and hidden by, the beak of the pedicle valve.

Pedicle interior with short, shallow delthyrial cavity; dental plates reduced to mere remnants. Muscular area small. Teeth slender, long.

Brachial valve with wide undivided hinge plate supported at the posterior by an expanded median septum. Crura flattened, long and slender, closely approximate. Crural bases enveloped by thickening of hinge plate and showing as low, rounded ridges bounding a shallow depression. Median septum long, thickening posteriorly, slender anteriorly, moderately elevated, reaching to about the middle of the valve.

Measurements in mm.—Holotype, length 26.0, width 26.8, length of brachial valve 23.5, thickness 12.6, width of fold 15.

Named in honor of Dr. Preston E. Cloud, Jr., who described the Permian brachiopods of Las Delicias, Coahuila.

Types.—Holotype, U.S.N.M. No. 115549b; figured paratypes, U.S.N.M. Nos. 115548a,b, 115549a, 115550a, I.G.M.

Horizon and locality.—Pinkish shales of the *Leiorhynchoidea* zone between the *Anidanthus* and *Composita* zones, loc. 806i, 806i′, 806q, 806u.

Discussion.—This species is characterized by its leiorhynchoid form, the coarse plications, strongly incurved beak, and the fact that the plications die out just anterior to the umbo on both valves. The Mexican species appear to be identical to those doubtfully referred by Girty to *Pugnax weeksi nobilis* from the phosphate beds of the Park City formation in Idaho. These specimens with their strong, wholly plicate valves deserve a new name to distinguish them from the partially plicate forms.

The writer has referred this species to the genus *Leiorhynchoidea* recently described by Cloud from the Permian area, Las Delicias, Coahuila. The cardinalia of the brachial valve agree well with those described by Cloud with the exception that denticulations in the sockets cannot be proved in the Monos material and it is probable that they are not present. Reference of Girty's *Pugnax weeksi nobilis* to the genus *Pugnoides* seems an error to the writer. The presence of the strong median septum eliminates the species from the genus *Pugnax* at once but the cardinalia are so like those of *Leiorhynchoidea* as described by Cloud and with the exception mentioned above, that the Monos specimens are referred to *Leiorhynchoidea.* The Monos specimens have a fairly broad and thick hinge plate which bears a slight median groove between lateral thickenings that undoubtedly represent the crural bases. No small chamber such as that occurring in *Pugnoides* was seen although it is possibly present as a feature of juvenile shells. *Leiorhynchoidea* is a common genus in the Permian at Las Delicias, Coahuila.

UNCINUNELLINA? PULCHRA Cooper, new species

Plate 14B, figures 6-15

Shell fairly large; subpentagonal in outline, with the width slightly exceeding the length. Brachial valve deeper than the pedicle valve. Posterior margins nearly straight, oblique laterally; lateral margins narrowly rounded, and anterior margin nearly straight. Anterior commissure strongly uniplicate. Surface costate, costae narrow, angular, separated by spaces not as wide as the costae. Sulcus occupied by 5 to 6 costae, 6 to 7 occurring on the fold and 6 to 9 on the flanks, the last 2 or 3 very small. Anterior half of surface marked by zigzag imbricating lines.

Pedicle valve moderately and quite evenly convex in lateral profile; gently convex in anterior profile but with the median portion flattened or depressed. Umbonal region narrowly swollen, the swelling continuing anteriorly to the place of origin of the sulcus at the middle of the valve. Sulcus deepening rapidly anteriorly but not very deep; tongue short and bluntly rounded. Flanks gently convex with steep slopes in the posterior parts but with gentle slopes at the anterior. Anteromedian portion of flanks bounding sulcus slightly elevated above the flank and strongly elevated above the fold at the anterior. Beak long, narrow, moderately incurved. Foramen small, circular, mesothyrid.

Brachial valve evenly but gently convex in lateral profile; broadly convex in anterior profile. Umbonal region moderately convex, somewhat depressed in the median region. Fold originating at the middle, not greatly elevated anteriorly and occupying about half the width at the front. Flanks slightly depressed below the fold, quite swollen and with steep slopes to the lateral margins.

Interior of pedicle valve with dental plates extending about one-quarter the valve length. Brachial interior with median septum supporting a hinge plate divided by a shallow chamber. Crura long and slender.

Measurements in mm.—Holotype, length 22.3, width 23.4, length of brachial valve 19.1, thickness 15.0, width of fold 13.0; paratype (U.S.N.M. No. 115571), length 17.2, width 18.0 (estimated on half measure), thickness 10.6, length of brachial valve 16.0.

Types.—Holotype, U.S.N.M. No. 115569; figured paratypes, U.S.N.M. Nos. 115570, 115571.

Horizon and locality.—Rare in the *Leiorhynchoidea-Cancrinella* zone, loc. 806i, 806q.

Discussion.—This species is characterized by its large size, standard

rhynchonellid form and the strong imbrications in the anterior portion of the valve. Rhychonellids are not common in the Permian of North America and usually belong to *Rhynchopora* and *Wellerella*. This species is somewhat doubtfully referred to *Uncinunellina*, a genus not hitherto recognized on this continent because of its finely costate exterior and the presence of discrete dental plates in the pedicle valve. The genotype of *Uncinunellina, U. theobaldi* Waagen, from the Permian of the Salt Range, India, has the square anterior of *Rhynchopora* and thus is differently shaped from the species under discussion. *U. jabiensis* from the same fauna, however, is suggestive of *U.? pulchra* Cooper, new species, but is somewhat smaller and with less costae in the sulcus and on the fold. No species comparable to *U.? pulchra* has yet been described from the Permian of North America.

RHYNCHOPORA TAYLORI Girty

Plate 15A, figures 1-21

Rhynchopora taylori Girty, U. S. Geol. Surv. Bull. 436, p. 34, pl. 3, fig. 8, a-c, 1910.—C. C. Branson, Univ. Missouri Studies Quart., vol. 5, No. 2, p. 34, pl. 2, figs. 17-19; pl. 3, figs. 5-9, 1930.

Shell of about medium size for the genus, pentagonal in outline; width about $1\frac{1}{4}$ times the length; posterior margins gently concave, lateral margins narrowly rounded; anterior margin very gently convex or straight; greatest width a short distance anterior to the middle. Surface costate; costae broader than the interspaces, rounded to subangular. Fold with 5 to 7 costae, the lateral ones often depressed below the others; sulcus with 4 to 6 costae and the flanks bearing 6 to 8 distinct costae and 1 or 2 indistinct ones. Puncta very fine, somewhat crowded.

Pedicle valve unequally convex in lateral profile, the greatest convexity situated anterior to the umbo and posterior to the middle. Anterior profile broadly concave, the sides of the depression steeply sloping medially. Beak narrow; umbonal region moderately swollen, the swelling continued as a low fold along the median portion of the sulcus. Beak ridges short, not strongly developed. Sulcus wide, occupying about half the shell width at the anterior margin. Sulcus originating about 5 mm. anterior to the beak, deepening rapidly. Tongue long, abruptly geniculated, flat, with each costa bearing a median depression. Flanks bounding sulcus gently concave in the posterior part bounding the swollen preumbonal area, but gently convex in the anterior half; flanks bounding deep part of sulcus moderately elevated, with steep sides and forming a broad plica. Foramen small, round.

Brachial valve gently convex in lateral profile, nearly a semicircle in anterior profile. Beak low, incurved and protruding beyond the posterior margin. Umbo very gently swollen but bearing a low median depression corresponding to the folded portion of the pedicle posterior. Fold originating slightly posterior to the middle, elevating slightly anteriorly and occupying about half the width at the front. Fold low, flat to gently convex in profile. Flanks depressed gently below the fold, moderately convex and with very steep sides. Anterolateral extremities elongated and bluntly pointed where they join with the anteriorly angulated flanks of the pedicle valve bounding the sulcus.

Interior details lacking.

Measurements in mm.—Hypotypes: (U.S.N.M. No. 115478), length 10.4, width 12.3, length of brachial valve 8.9, thickness 8.3, width of fold 7.1; (U.S.N.M. No. 115479), length 13, width 16.1, length of brachial valve 11.5, thickness 11.5, width of fold 7.8; (U.S.N.M. No. 115477), length 12.2, width 15.7, length of brachial valve 10.6, thickness 10.3, width of fold 8.9.

Hypotypes.—U.S.N.M. Nos. 115476-115479, I.G.M.

Horizon and locality.—Rare in the *Composita* zone, loc. 806c, 806h, 806r, 806v; rarer still in *Dictyoclostus* zone, loc. 806-l; *Anidanthus* zone, loc. 806m, 806n; *Leiorhynchoidea-Cancrinella* zone, loc. 806i; *Spiriferellina* zone, loc. 806d′.

Discussion.—The rhynchonelloid form and punctate exterior of this species serve to place it in *Rhynchopora.* It is a very variable species, as a study of the illustrations of Monos specimens will indicate. The variation is shown in the relation of length to width which varies between 0.78 and 0.84. The width of the fold and sulcus is variable as is also the number of costae appearing in the sulcus and on the fold. This species is widely distributed in the North American Permian occurring in the Phosphoria formation of Wyoming and Idaho, the Word formation of the Glass Mountains, Tex., and somewhat doubtfully in the Permian of Coahuila, Mexico.

RHYNCHOPORA TAYLORI ROTUNDA Cooper, new subspecies

Plate 15C, figures 27-31

Known specimens of small size for the genus, wider than long, pentagonal in outline with straight posterior margins, somewhat narrowly rounded lateral margins, and a slightly convex anterior margin. Costate, with 4 to 5 costae in the sulcus and 5 to 6 on the fold. Flanks marked by 5 and possibly 6 costae.

Pedicle valve with gently convex lateral and anterior profiles. Um-

bonal and median regions very slightly swollen, the swelling continued anteriorly in the sulcus, the floor of which is gently convex. Sulcus originating at about the middle, wide and shallow. Tongue long, geniculated toward the brachial valve in a broad curve. Flanks narrow, gently convex. Beak erect.

Brachial valve flatly convex but with the umbo moderately curved in lateral profile; anterior profile semielliptical. Fold low, gently convex in section, originating at or anterior to the middle. Flanks moderately convex, steep-sided.

Interior unknown.

Measurements in mm.—Paratype, length 10.9 plus, width 12.5, length of brachial valve 9.8, thickness 8.0, width of fold 7.4; holotype, length 9.6, width 10.7?, length of brachial valve 8.6, thickness 7.6, width of fold 5.6.

Types.—Holotype, U.S.N.M. No. 115480; paratype, I.G.M.

Horizon and locality.—*Spiriferellina* zone, loc. 806d', 806f, 806g.

Discussion.—This variety differs from *R. taylori taylori* Girty in its less robust form, smaller size, somewhat more rotund outline, and smaller number of costae in the sulcus and on the fold. This variety is rare and, so far as known, is confined to the *Spiriferellina* zone.

RHYNCHOPORA BICOSTATA Cooper, new species

Plate 15B, figures 22-26

Shell of about medium size for the genus, slightly wider than long, subpentagonal in outline. Posterior margins gently concave, lateral margins broadly rounded; anterior margin straight. Surface costate; costae narrowly rounded, separated by narrow grooves. Fold narrow, with 3 costae; sulcus narrow with 2 broad costae, and the flanks marked by 5 to 6 costae, the last one indistinct. Puncta fine and closely crowded.

Pedicle valve gently convex in lateral profile, gently convex in anterior profile. Umbonal region gently swollen; beak slightly incurved. Sulcus narrow, moderately deep at the anterior, occupying about half the shell width, and originating at about the middle. Tongue narrow and short, geniculation at about 90° but in a narrow curve. Flanks gently concave but upturned slightly along the margins.

Brachial valve with the posterior half moderately convex but the anterior half nearly flat in lateral profile. Anterior profile narrowly semielliptical. Fold narrow, originating at the middle, scarcely elevated except at the anterior margin. Flanks swollen and with steep sides, extended considerably in an anterior direction to unite with the pedicle valve.

Measurements in mm.—Holotype, length 12, width 13.5, length of brachial valve 10.5, thickness 10.4, width of fold 5.2.

Holotype.—U.S.N.M. No. 115481.

Horizon and locality.—*Composita* zone, loc. 806r.

Remarks.—This species in its form and general appearance is related to *R. taylori* with which it occurs in the *Composita* bed. It differs from that species in being more rounded in outline (L/W=0.89), having a narrower and less-pronounced fold with only 3 costae instead of 5 to 6. The 2 prominent and broad costae of the sulcus are in strong contrast to the 4 to 6 occurring in the sulcus of *R. taylori.*

WELLERELLA HEMIPLICATA Cooper, new species

Plate 15E, figures 41-63; plate 16A, figures 1-8

Shell large for the genus, subtriangular to subpentagonal in outline. Exterior variable; posterior margins nearly straight to gently concave and descending to broadly rounded lateral margins; anterior margin broadly curved. Anterior commissure strongly uniplicate. Surface smooth in the posterior half but strongly costate in the anterior half. Sulcus occupied by 1 to 4 costae, the fold by 2 to 5 costae, and the flanks marked by 2 or 3 costae.

Pedicle valve moderately and evenly convex in lateral profile; slightly concave to gently convex in anterior profile. Umbonal region moderately strongly swollen; median region moderately swollen. Sulcus originating at or near the middle, shallow, forming a short, broad tongue. Sulcus occupying about half the shell width at the anterior. Flanks bounding sulcus flattened to concave between the costa bounding the sulcus and the margin, and with moderately steep slopes. Beak gently incurved, narrow; foramen as usual in the genus.

Brachial valve gently convex in lateral profile; almost semicircular in anterior profile. Fold short, originating slightly anterior to the middle, not strongly elevated above the flanks and flattened in profile. Flanks convex and with steep slopes to the margins. Umbonal and median regions swollen.

Pedicle interior with short dental plates. Interior of brachial valve with short, undivided hinge plate, long, curved crura, and a low median septum united to the lower surface of the hinge plate at the posterior apex.

Measurements in mm.—Holotype, length 18.3, width 16.3, length of brachial valve 16.7, thickness 10.1, width of fold 10.1; paratypes: (U.S.N.M. No. 115535), length 16.1, width 15.8, length of brachial valve 14.2, thickness 11.2, width of fold 10.4; (U.S.N.M. No. 115533), length 17.0, width 15.0, length of brachial valve 14.6, thickness 10.4,

width of fold 9.6; (I.G.M.), length 19.8, width 18.2, length of brachial valve 17.6, thickness 10.9, width of fold 12.1; (U.S.N.M. No. 115534), length 17.5, width 16.2, length of brachial valve 15.3, thickness 11.2, width of fold 9.9; (U.S.N.M. No. 115536), length 13.8, width 14.5, length of brachial valve 12.6, thickness 10.5, width of fold 8.6.

Types.—Holotype, U.S.N.M. No. 115532; figured paratypes, U.S.N.M. Nos. 115534-115538a,b, I.G.M.; unfigured paratype, U.S.N.M. No. 115533.

Horizon and locality.—Confined to the *Composita* zone, loc. 806c, 806h, 806h′, 806r.

Discussion.—This species is characterized by its large size and partially costate valves. *Wellerella lemasi* is the only species approaching it in size but will not be confused with it because of its more completely costate valves. Variability is one of the characteristics of *W. hemiplicata* as may be seen in the fact that 1 to 3 costae may occupy the sulcus. Considerable variation in shape also occurs but this may be caused by distortion of the specimens during alterations of the rock enclosing them. Some of the more elongated specimens have very obviously been squeezed laterally whereas some of the rotund forms may have been deformed by crushing in an anterior-posterior direction.

WELLERELLA LEMASI Cooper, new species

Plate 16D, figures 28-54

Shell fairly large for the genus, slightly wider than long, subtriangular to subpentagonal in outline. Posterior margins slightly concave and forming an angle of slightly more than 90° with the beak; anterolateral extremities narrowly rounded; anterior margin nearly straight. Anterior commissure strongly uniplicate. Anterior three-quarters of surface strongly costate; costae narrowly rounded to subangular, 2 occupying the sulcus, more rarely 1 or 3, 3 on the fold, rarely 2 or 4 costae, and 5 or 6 present on the flanks.

Pedicle valve moderately convex in the umbonal region but concave in the anterior half when viewed in lateral profile; anterior profile broadly sulcate to nearly flat. Sulcus originating at about the middle, widening and deepening rapidly anteriorly to occupy about half the width at the front margin. Umbonal and median areas gently but somewhat narrowly swollen. Flanks gently convex in the posterior part but gently to moderately concave just inside the anterolateral margin and with the margins deflected noticeably toward the pedicle

valve. Slopes bounding sulcus steep; tongue short, truncated, but serrate. Beak narrow, gently incurved; foramen elongate elliptical, submesothyrid.

Brachial valve gently convex in lateral profile; semicircular in anterior profile with a somewhat flattened summit and steep sides. Umbonal region flattened, faintly sulcate; fold originating at about the middle generally flattened and not strongly elevated above the flanks even at the anterior end. Median costa of fold commonly depressed below the others. Anterior extremity of fold slightly rounded. Flanks convex, moderately steep.

Interior as usual for the genus.

Measurements in mm.—Holotype, length 16.0, width 16.9, length of brachial valve 14.1, thickness 13.9, width of fold 7.6; paratypes: (U.S.N.M. No. 115543a), length 17.0, width 16.0, length of brachial valve 14.4, thickness 10.4, width of fold 7.2; (U.S.N.M. No. 115544), length 13.9, width 14.0, length of brachial valve 12.6, thickness 18.8, width of fold 6.3; (U.S.N.M. No. 115542a), length 14.4, width 17.2, length of brachial valve 12.9, thickness 15.8, width of fold 8.3.

Types.—Holotype, U.S.N.M. No. 115541; figured paratypes, U.S.N.M. Nos. 115542a,b, 115543a,b,c, 115544; unfigured paratype, I.G.M.

Horizon and locality.—Abundant in the *Composita* zone, loc. 806c, 806h, 806h', 806r, 806v, rare in the *Leiorhynchoidea-Cancrinella* zone, loc. 806i.

Named in honor of Sr. Manuel Lemas, manager of Moreno Mines, whose hospitality made our stay at Antimonio a real pleasure.

Discussion.—In size this species approaches its associate *W. hemiplicata* but is easily differentiated by the fact that it is more completely costated and has a more depressed triangular outline. It is similar in form to *W. lemasi minor* but is a much larger species with a deeper sulcus and more exaggerated anterolateral extremities in the brachial valve.

WELLERELLA LEMASI MINOR Cooper, new subspecies

Plate 16C, figures 14-27

Shell moderately large for the genus, subtriangular to subpentagonal in outline, slightly wider than long with the greatest width at or somewhat anterior to the middle. Posterior margins nearly straight forming an angle with the beak of slightly more or slightly less than 90°; lateral margins narrowly rounded; anterior margin broadly convex to nearly straight. Anterior commissure strongly uniplicate. Surface costate, costae originating 5 to 7 mm. anterior to the beak, 3 costae

(rarely 4 or 5) occupying the fold, 2 costae (rarely 3 or 4) occurring in the sulcus, and 4 costae occupying the flanks.

Pedicle valve moderately convex in the posterior half and somewhat flattened in the anterior half when viewed in lateral profile; anterior profile broadly sulcate. Beak moderately long, incurved. Umbonal region narrowly swollen, the swelling extending to about the middle where the sulcus originates. Sulcus deepening rapidly anteriorly, and extended into a moderately long tongue that is bent nearly at a right angle by a broad curve. Costae bounding sulcus considerably elevated at the anterior. Flanks bounding sulcus flattened and with gentle slopes to the margins, and with anteromedian extremities elevated. Anterolateral margins of flanks deflected slightly toward the pedicle valve. Foramen small, elongate oval, submesothyrid.

Brachial valve flatly to moderately convex in lateral profile; transversely semielliptical in anterior profile. Fold originating at about the middle, not strongly elevated above the flanks at the anterior extremity, often with median costa slightly depressed. Flanks moderately rounded, with steep sides, anterolateral extremities moderately extended toward the pedicle valve. Umbonal region flattened to slightly swollen.

Interior of pedicle valve with short dental plates. Interior of brachial valve with undivided short hinge plate and moderately long curved crura.

Measurements in mm.—Holotype, length 12.5, width 13.8, length of brachial valve 10.7, thickness 10.0, width of fold 6.9; paratypes: (U.S.N.M. No. 115546), length 12.2, width 12.3, length of brachial valve 10.4, thickness 8.2, width of fold 7.8; (U.S.N.M. No. 115547b), length 12.8, width 15.2, length of brachial valve 11.2, thickness 8.4, width of fold 7.5.

Types.—Holotype, U.S.N.M. No. 115545; figured paratypes, U.S.N.M. Nos. 115546, 115547a,b; unfigured paratypes, I.G.M.

Horizon and locality.—Confined to the *Spiriferellina* zone, loc. 806b, 806d, 806d', 806f, 806g, 806h^2, 806s, 806w.

Discussion.—*Wellerella lemasi minor* in form and outline is very similar to *W. lemasi.* However, it does not attain the large size reached by *W. lemasi* although a few specimens assigned to this subspecies approach the species in size.

WELLERELLA ROTUNDA Cooper, new species

Plate 15D, figures 32-40

Shell of about medium size for the genus, subtriangular to suboval in outline with the length and width about equal. Greatest width at

or near the middle. Anterior commissure strongly uniplicate. Surface of anterior half costate; posterior half smooth. Costae narrowly rounded, separated by grooves narrower than the costae. Fold marked by 3 costae, sulcus by 2 costae, and the flanks by 5 costae.

Pedicle valve almost flat in lateral profile and faintly convex in anterior profile. Umbonal region gently convex; median region nearly flat. Sulcus originating slightly anteriorly to the middle, short and moderately deep. Tongue short and narrow. Costae bounding sulcus slightly elevated anteriorly. Flanks very gently convex in posterior portion but flattened just inside the anterior and anterolateral margins. Beak short, slightly incurved.

Brachial valve unevenly convex in lateral profile with the maximum convexity in the anterior part. Anterior profile strongly arched with gently convex surface and steep sides. Fold low and narrow, originating near the middle, slightly elevated above the surrounding flanks. Umbonal region nearly flat. Flanks swollen and rounded and with nearly vertical sides. Interior of brachial valve with undivided hinge plate as usual in the genus.

Measurements in mm.—Holotype, length 12.1, width 11.9, length of brachial valve 10.3, thickness 9.7, width of fold 5.0. Paratype, (I.G.M.), length 11.0 plus, width 11.2, length of brachial valve 9.7, thickness 7.0, width of fold 5.1.

Types.—Holotype, U.S.N.M. No. 115539; figured paratype, I.G.M; unfigured paratype, U.S.N.M. No. 115540.

Horizon and locality.—Confined to the *Leiorhynchoidea-Cancrinella* zone, loc. 806i.

Discussion.—*Wellerella rotunda* is characterized by its narrow fold and sulcus. This species is of about the same size as *W. lemasi minor* which occurs higher in the section. It has much more subdued ornamentation and the fold and sulcus are not so strongly developed. In outline this species resembles *Pugnax pinguis* Girty which is undoubtedly a member of the genus *Wellerella* but differs in having only 2 costae in the sulcus whereas the Texas species has 3.

WELLERELLA species

Plate 16B, figures 9-13

Shell of about medium size for the genus, elongate triangular to pentagonal in outline; length slightly greater than the width. Greatest width slightly anterior to the middle. Anterior commissure strongly uniplicate. Surface costate; costae rounded, separated by furrows

narrower than the costae. Costae numbering 4 on the fold, 3 in the sulcus, and 7 on the flanks.

Pedicle valve unevenly convex in lateral profile, the posterior two-thirds having the greatest convexity; anterior profile gently convex. Beak elongated, erect; umbo narrowly swollen, the swelling continuing to the point of origin of the sulcus where it is lost. Sulcus originating slightly anterior to the middle, narrow but deep and continued anteriorly as a short, bluntly rounded tongue. Flanks concave anterolaterally and deflected in a pedicle direction to produce sharp projections at the anterior bounding the deepest part of the sulcus. Lateral slopes convex and steep.

Brachial valve moderately strongly convex in lateral profile and strongly vaulted in anterior profile. Umbonal region swollen and smooth; fold originating near the middle, moderately strongly elevated anteriorly and rounded in profile. Flanks swollen and with steep lateral slopes.

Interior not known.

Measurements in mm.—Holotype, length 13.6, width 13.4, thickness 10.5, width of fold 6.0.

Figured specimen.—I.G.M.

Horizon and locality.—From the *Leiorhynchoidea-Cancrinella* zone, loc. 806i.

Discussion.—The single specimen collected occurs with *W. rotunda* from which it differs in having a more elongate-triangular outline, 3 costae in the sulcus and 4 on the fold. It differs from *W. lemasi* and *W. hemiplicata* for the same reasons.

STENOSCISMA species

Plate 14A, figures 1-5

Shell of about medium size for the genus with length and width probably about equal; maximum width in the anterior half. Anterolateral margins narrowly rounded; anterior margin gently rounded. Anterior commissure strongly uniplicate. Surface costate; costae low, rounded, somewhat subdued, separated by furrows narrower than the costae. Fold occupied by 5 costae, sulcus with 4 costae, and flanks marked by 4 costae located on the part of shell adjacent to fold and sulcus; umbonal slopes smooth or with concentric growth lines and growth varices only; posterolateral areas without costae.

Pedicle valve of gentle convexity in lateral profile; and very gently convex to nearly flat in anterior profile. Umbonal and beak regions not preserved. Sulcus originating at about the middle, broad and

shallow; tongue of pedicle valve short and broadly rounded. Flanks bordering sulcus gently convex but narrowly rounded and with steep slopes in the posterolateral regions.

Brachial valve gently and evenly convex in lateral profile and with the greatest convexity at about the middle. Anterior profile somewhat narrowly convex. Umbonal region moderately swollen, the swelling increasing somewhat to the median area and on to the anterior margin as a low rounded fold. Origin of fold slightly posterior to the middle. Flanks well rounded, depressed below the fold and with prominent anterolateral extremities. Umbonal and lateral slopes steep.

Interior of pedicle valve with large and deep spondylium; median septum low in the brachial valve.

Measurements in mm.—Figured specimen, length not measurable but probably in the neighborhood of 24.0; length of brachial valve 19.4, width 23.0, thickness 13.4, width of fold 12.7.

Figured specimen.—U.S.N.M. No. 115574.

Horizon and locality.—Probably from *Leiorhynchoidea-Cancrinella* zone, loc. 806i; *Dictyoclostus* zone, loc. 806k′.

Discussion.—Two specimens referrable to this genus were found, one is the specimen figured and the other is the right half of a large brachial valve with a small portion of the pedicle valve attached. This specimen by its sparse and subdued costation indicates the same species as that of the smaller specimen figured, but it was, when complete, a much larger individual. The length of the brachial valve was in the neighborhood of 30 mm.

In its general leiorhynchoid appearance this species is unlike any other yet described in North America. It has the large size of *S. venustum* (Girty) but is not so strongly costate as that species. It is very suggestive of the specimens figured as *Camarophoria crumena* Martin by Tschernyschew from Permian beds in Russia.

COMPOSITA GRANDIS Cooper, new species

Plate 17A, figures 1-5; plate 17B, figures 6-18; plate 18, figures 1-10

Species large for the genus, variable, generally slightly longer than wide; subpentagonal in outline with the greatest width located at about the middle. Posterior margins gently curved; lateral margins moderately strongly curved; anterior margin produced, subtruncate. Anterior commissure strongly uniplicate. Surface marked only by concentric growth lines and varices of growth.

Pedicle valve moderately convex in lateral profile with the strongest curvature in the umbonal region; umbonal slopes steep; anterior pro-

file moderately convex but with the median portion gently sulcate. Beak suberect; umbo narrowly swollen. Median region full. Sulcus shallow, broad, originating about 10 mm. anterior to the beak. Median line of sulcus marked by a shallow but narrow groove that extends nearly to the front margin but disappears on the tongue before the front margin is reached. Tongue moderately long, broadly rounded at the extremity, with angle of geniculation not quite 90°. Flanks moderately convex, with steep slopes to the margins. Foramen small, round.

Brachial valve gently convex in lateral profile with the umbonal region just anterior to the umbo forming the most convex part; anterior profile moderately but broadly convex. Umbonal region strongly swollen, protruding posterior to the posterior margin. Median region swollen, the swelling continued anteriorly. Fold short, confined to anterior quarter, defined by fairly abrupt folding of anterolateral extremities. Flanks gently swollen especially in lateral and posterolateral areas.

Interior, hinge plate small, imperforate, supported by short lateral septa. Socket ridges prominent. Spiral coils forming abruptly expanding, short cones composed of tightly coiled spires.

Measurements in mm.—Holotype, length 51.0, width 45.3, thickness 31.4, length of brachial valve 44.8; paratypes: (U.S.N.M. No. 115516), length 44.3, width 43.0, thickness 25.3, length of brachial valve, 38.7; (I.G.M.) length 49.2, width 47.5, thickness 27.5, length of brachial valve 42.2; (U.S.N.M. No. 115517), length 35.2, width 36.6, thickness 21.0, length of brachial valve 31.6; (U.S.N.M. No. 115520), length 34.5, width 29.6, thickness 20.0, length of brachial valve 29.6; (U.S.N.M. No. 115519), length 48.0, width 37.8, thickness 28.6, length of brachial valve 41.0; (U.S.N.M. No. 115518), length 49.0, width 41.7?, thickness 32.5, brachial valve 41.5?.

Types.—Holotype, U.S.N.M. No. 115522; figured paratypes, U.S.N.M. Nos. 115516, 115517, 115520, 115521, 115591, I.G.M.; unfigured paratypes U.S.N.M. 115518, 115519, I. G. M.

Horizon and locality.—Abundant in *Composita* zone, loc. 806c, 806h, 806h′, 806r, 806v; rare in *Dictyoclostus* zone, loc. 806k, 806k′, 806p, 806x, 806z; still rarer in *Spiriferellina* zone, loc. 806b, 806d′, 806f, 806g.

Discussion.—This species attains the largest size of any known *Composita* and occurs in countless numbers in the Monos Hills particularly in the *Composita* zone. The abundance of the species is the reason for naming this most useful key zone of the area. It is not confined to this zone but is quite rare to common in other parts of the

Monos formation. Specimens occurring in considerable abundance in the *Dictyoclostus* zone at the Moreno house are poorly preserved but show no features that will distinguish them from higher specimens. This is true also of the abundant compositas that can be found in a zone not far above the *Anidanthus* zone in the low hill east of the Moreno house. This zone may be a part of the *Dictyoclostus* zone but the point has not yet been settled.

Recovery of good specimens from the prolific *Composita* zone is very difficult. The species as described herein is based on about 40 fairly well-preserved specimens. Actually it was not possible to obtain sufficient material to show the full variation of the species, which appears to be quite considerable. Some of the variation is undoubtedly due to distortion subsequent to burial but this is not true of two of the aberrant paratypes which are very well preserved. The variation consists chiefly in aberrations in the length/width ratio. The majority of specimens are slightly longer than wide and a few fairly slender specimens are wider than long. The length/width ratio varies between 0.98 and 1.27. The most extreme length/width ratio recorded is 0.94 but the specimen is somewhat distorted.

Three other comparable species of *Composita* are known. One is *C. gigantea* C. Branson from the Phosphoria formation of Wyoming. This species is based on a single specimen figured in lateral view only. Measurements given are: Length 60 mm. (this measure taken from the illustration is 51 mm.), width 45 mm., thickness 40 mm. The length/width ratio in this species indicated by the corrected length is well within the range of this ratio in *C. grandis* but the thickness of *C. gigantea* is far greater than that observed in the thickest of the Mexican specimens (32.5 mm.). *Composita gigantea,* by virtue of its greater thickness, presents a different lateral profile than that of *C. grandis.* Branson's figure thus reveals the brachial valve to be strongly and evenly convex with a steep anterior slope and the maximum convexity at the middle. In the Mexican species, on the other hand, the anterior slope is long and gentle and the maximum convexity is located just anterior to the umbo.

The second comparable species, also described by Branson, is called *C. plana.* Although crushed, this species has some of the features of *C. grandis,* such as the deeply impressed line in the sulcus of the pedicle valve. Branson described this species as wider than long, and if his measurements of the holotype of *C. plana* are correct the length/width ratio of his species falls well without that of *C. grandis.* A paratype figured by Branson indicates a nearly circular specimen. The fold is indicated in the description as steep and prominent and partially

bifurcated near the margin. These features do not appear on *C. grandis.* Branson's species suggests *C. mira* (Girty), which is the third species comparable to *C. grandis.*

The name *Composita mira* is based on specimens collected from the Phosphoria formation during the 40th Parallel Survey by Clarence King which F. B. Meek identified as *Athyris roissyi* L'Éveillé. Girty renamed these specimens. His species differs from *C. grandis* in having a narrower fold at the anterior, in a generally smaller size, and in being proportionally wider. Furthermore the beak region of *C. grandis* is longer, fuller, and the foramen is larger than that of *C. mira.*

Specimens of *Composita* taken from the *Spiriferellina* zone are generally smaller than those found in the *Composita* zone but no features were discovered, other than size, that would differentiate them as a species.

PSEUDOMARTINIA MARTÍNEZI Cooper, new species

Plate 19A, figures 1-23

Shell of about medium size for the genus, elongate ovate to subrhomboidal in outline with the length slightly greater than the width. Posterior margins broadly but unevenly rounded, the greater curvature in the posterior half giving a shouldered appearance to the shell. Anterior margin narrowly rounded. Greatest width located at or posterior to the middle. Anterior commissure gently but narrowly uniplicate. Surface where exfoliated marked by fine radial threads most conspicuous on the flanks, but smooth or with concentric growth varices where intact.

Pedicle valve with unequally convex lateral profile, the greatest convexity located in umbonal region. Anterior profile broadly convex. Umbo narrowly swollen, the swelling continued anteriorly to about the middle. Sulcus scarcely defined, the anterior portion of the valve being extended anterodorsally as a short, narrowly rounded tongue. Flanks rounded and steep in the posterolateral regions but somewhat flattened and much less steep in the anterolateral areas bounding the sulcus. Beak incurved, overhanging the delthyrium. Interarea narrow, a mere remnant bordering the very wide, open delthyrium.

Brachial valve gently but unevenly convex, the greatest convexity located in the posterior half, the anterior half flattened to barely perceptibly concave. Umbo narrowly swollen and extended anteriorly as a moderately narrow fold. Flanks bounding fold steep, flat to perceptibly concave in profile. Beak small, short, protruding slightly posterior to the nearly straight posterior margin.

Interior of pedicle valve without dental plates but with short oblique lamellae on each side of the delthyrial edge. Brachial interior short with obliquely flattened crural bases.

Named in honor of Jesús Martínez Portillo, librarian of the Instituto Geológico de México.

Measurements in mm.—Holotype, length 20.2, width 18.2, length of brachial valve 17.2, hinge width 10.3, thickness 12.9; paratypes: (U.S.N.M. No. 115567a), length 23.1, width 20.9, length of brachial valve 19.4, hinge width 11.8, thickness 14.4, width of fold 8.0; (U.S.N.M. No. 115567c), length 9.5, width 8.8, length of brachial valve 8.7, hinge width 6.2, thickness 6.9.

Types.—Holotype, U.S.N.M. No. 115565; figured paratypes, U.S.N.M. Nos. 115566a,b, 115567a-c, I.G.M.

Horizon and locality.—Confined to the *Composita* zone, loc. 806h, 806r.

Discussion.—This is not a common species in the *Composita* zone but a few fine specimens were found after considerable search. All the specimens are silicified but they must have been somewhat weathered before silicification took place because most of them show the fine radial lines of the interior portion of the shell. Some of the specimens show unweathered portions of the surface which are smooth except for concentric growth lines.

This species is very similar to *Martinia rhomboidalis* Girty, which occurs in the Capitan Formation in west Texas. The Mexican species differs in having a more slender lateral profile, somewhat more elevated pedicle beak, and wider gap between the pedicle and brachial beaks in lateral profile. The Mexican species also tapers more anteriorly and has a much less prominent and much narrower brachial fold and consequently a narrower pedicle tongue. No trace was seen of the indistinct linear depression mentioned by Girty as occurring in the pedicle valve.

NEOSPIRIFER, species 1

Plate 20E, figures 25-27

Shell of about the usual size for the genus, semielliptical in outline, wider than long with narrowly rounded lateral margins and inwardly sloping anterolateral margins. Hinge straight, not equaling the greatest shell width which is located near the middle. Anterior commissure strongly uniplicate. Surface fascicostellate; fold and sulcus marked by subequal costellae not arranged in bundles. Flanks bounding sulcus marked by 3 or 4 distinct fascicles strongly developed in the posterior

and median regions but dying out in the anterior portions of the valves. Fascicles generally composed of 3 to 5 costellae.

Pedicle valve moderately convex in lateral profile; sulcus broad and deep, originating at the umbo and continued anteriorly as a moderately long, acutely pointed tongue. Flanks bounding sulcus moderately narrowly rounded with moderate slopes to the cardinal extremities and lateral margins. Interarea moderately long, curved; beak incurved, narrowly pointed.

Brachial valve moderately convex in lateral profile and with the maximum convexity at the middle; anterior profile broadly convex. Umbo somewhat narrowly swollen and protruding posterior to the posterior margin; fold originating on the umbo and extending to the anterior margin, narrowly rounded to subcarinate in section; fold moderately strongly elevated above the flanks. Flanks somewhat inflated and with moderately steep slopes to the margins.

Measurements.—None of the specimens is sufficiently entire to make complete measurements possible. One specimen has a length of nearly 50 mm. even in its deformed state. This length suggests that the species had a width of at least 80 mm., a very large brachiopod.

Figured specimens.—U.S.N.M. Nos. 115496a, 115498, I.G.M.

Horizon and locality.—Rare in the *Dictyoclostus* zone, loc. 806k.

Discussion.—No good specimens of this species were collected. The few fragmentary individuals found indicate a large *Neospirifer* characterized by a moderately deep sulcus in the pedicle valve, and a strongly fasciculate surface. The fasciculae are strongest in the posterior half of the valve but became lost anterior to the middle. The specimens are most suggestive of *N. costellus* R. E. King from the Leonard formation of the Glass Mountains. This species is characterized by the strong bundling of innumerable costellae but the fasciculation appears to extend to the margins of the valves according to King's figures. Melting of the fascicles into the general convexity of the valves in an anterior direction is a feature of *N. bakeri,* which is like that of the Mexican specimens. The Monos species thus combines features of the two Texas species but better specimens will have to be found before a correct identification is possible.

NEOSPIRIFER, species 2

Plate 20F, figure 28

Among the unnamed species of brachiopods found in the Monos formation is a large *Neospirifer* represented by two fragmentary pedicle valves found in the *Dictyoclostus* zone just west of the Moreno

house. The two specimens indicate an unusually large brachiopod with fairly strong costae for the genus. The interarea is short and strongly curved; an incurved beak overhangs the open delthyrium. Interarea unusually narrow. The sulcus originated some distance anterior to the beak and is broad and shallow. The flanks are moderately convex but the umbonal slopes are steep, a reflection of the inflated umbo. The costae are strong and bifurcated or trifurcated but with little bundling. No other species quite like this one has yet been described.

Horizon and locality.—*Dictyoclostus* zone, loc. 806k.

Figured specimen.—I.G.M.

SPIRIFERELLA? SCOBINOIDEA Cooper, new species

Plate 19C, figures 28-35

Specimens incomplete and poorly preserved; of medium size for the genus, length and width probably subequal; lateral margins gently curved; hinge wide, slightly less than the greatest shell width; cardinal extremities slightly greater than a right angle, anterior commissure uniplicate. Surface costate, costae broadly rounded, separated by narrowly rounded, deep furrows often less than half the width of the costae; increase in costae by bifurcation.

Pedicle valve with unevenly convex lateral profile, the greatest curvature occurring in the umbonal region. Anterior profile strongly vaulted. Umbonal region tumid and with steep umbonal slopes. Umbo narrowing rapidly to form the narrow, strongly incurved beak. Sulcus originating on the umbo with a very narrow groove which continues to the anterior; sulcus broad and shallow anteriorly from the umbo and occupied by 2 strong costae bifurcated from the bounding costae. Crest of flanks marked by 2 strong costae; flanks somewhat narrowly rounded, with steep lateral slopes in the posterior but becoming less steep anteriorly. Interarea short, strongly curved, apsacline.

Brachial valve moderately convex in lateral profile and broadly convex in anterior profile. Umbonal region gently swollen, with short gentle slopes to the cardinal extremities. Fold narrow, not greatly elevated above the flanks, with 3 to 5(?) costae. Flanks depressed below the fold, moderately swollen and with gentle slopes to the margins.

Interior of pedicle valve with deep delthyrial cavity usually filled with callus; dental plates strong; teeth small; muscular area elongate-ovate, located anterior to the dental plates; diductor scars long and narrow; adductor impressions long and slender, separated by a low, slender ridge.

Measurements in mm.—Specimens mostly fragmentary.

Types.—Holotype, U.S.N.M. No. 115491; figured paratypes,

U.S.N.M. Nos. 115492a,b, I.G.M; unfigured paratype, U.S.N.M. No. 115492c.

Horizon and locality.—Confined to the *Anidanthus* zone, loc. 806m, 806n.

Discussion.—This species is characterized by its strong, wide, and broad costae separated by very narrow striae. No first-rate specimens were found although fragmentary specimens are quite numerous. The species is much thickened in the posterior portion of the pedicle valve which is the only part that is abundant and well preserved. The anterior portion of the pedicle valve and the brachial valve were much thinner than the posterior of the pedicle valve and were damaged or not preserved. This is a common condition in spiriferoids from all parts of the Paleozoic.

Generic assignment of this species was also difficult because it is not a well-known type in North America. The assignment is very largely based on the belief that *S. scobinoidea* is closely related to *S. scobina* (Meek). The genus *Spiriferella* until recently was not recognized in North American Permian deposits but was identified in the Mississippian of the Mississippi Valley. Cooper showed that the American Mississippian specimens so referred actually were unrelated to *Spiriferella* and proposed a new name for them. *Spiriferella* of the Permian was shown to be an impunctate genus characterized by a peculiar external ornamentation as well as having certain internal characters. The exterior feature of importance is a fine granulation that covers the entire external surface. The exterior of *S. scobina* from the Permian of Nevada is covered by minute granules and is thus placed in *Spiriferella*. Although the Mexican specimens show none of these granules because the specimens are silicified, they are assigned to *Spiriferella* because of other similarities to *S. scobina,* particularly the broad costae.

Like *S. scobina,* the Mexican species is characterized by coarse costae but *S. scobinoidea* differs from the Nevada species in being a much less robust form with much more arched umbonal region, and the details of ornamentation are quite distinctive. The Nevada species has a wide, shallow sulcus and a broad, low fold. In the posterior region of *S. scobina* the sulcus is occupied by a single costa but in a short distance anteriorly a costa is implanted on each side of the primary one. At the front of the holotype 5 costae appear in the sulcus. In the Mexican species on the other hand, a narrow groove extends from the umbo to the margin of the specimens (which are incomplete) but 2 large costae appear on the slopes of the sulcus. The fold at the posterior contains a prominent median costa and a less conspicuous one on each side. The fold thus appears to have 3 costae only.

SPIRIFERELLA, species 1

Plate 19B, figures 24-27

Three fragmentary specimens represent an undescribed species of *Spiriferella;* the specimens are inadequate to establish a new species.

Pedicle valve gently convex in both profiles marked by six strong subangular plications, separated by subangular troughs of equal dimensions except for the median furrow which is wider and deeper than the others and serves as a median sulcus. Umbonal region narrow and convex, tapering to a small, strongly incurved beak that overhangs a convex pseudodeltidium. Hinge narrow, interarea short and curved.

Brachial valve gently convex in lateral profile, with a swollen but small umbonal region; anterior profile broadly and gently convex. Hinge narrow; median 4 costae elevated strongly above lateral 2 and forming a very broad fold. Median 2 costae of fold subparallel, low, but slightly elevated above the level of the larger costae on the flanks of the fold. Median 2 costae separated by a narrow furrow of about the same width as the bounding costae. Flanks depressed below the broad fold, gently convex.

Dimensions.—Too imperfect to measure.

Figured specimens.—U.S.N.M. Nos. 115493a,b.

Horizon and locality.—Lower part of the *Leiorhynchoidea-Cancrinella* zone, loc. 806i; *Dictyoclostus* zone, loc. 806k.

Discussion.—This species will not be confused with any other spiriferoid occurring in the Monos formation. It is strongly suggestive of the *Spirifer* (*Elivina*) *sulcifer* Shumard identified by R. E. King from the Word formation in the Glass Mountains of Texas. That species is provided with a broad fold and with broad subangular costae. It is also strongly papillose on the exterior, having ornamentation much like that of the type species of *Spiriferella.* The latter name is the older one and is used here in preference to Fredericks's name, *Elivina.*

SPIRIFERELLA, species 2

Plate 20A, figures 1-3

A large but imperfect specimen with valves injured at the anterior is referred doubtfully to this genus. The specimen indicates another species that is probably new.

Figured specimen.—I.G.M.

Horizon and locality.—*Anidanthus* zone, loc. 806n.

HUSTEDIA MEEKANA (Shumard)

Plate 20D, figures 16-24

Retzia(?) Meekana SHUMARD, Trans. Acad. Sci. St. Louis, vol. 1, p. 295, 1859.
Retzia Meekiana SHUMARD, ibid., p. 395, pl. 11, figs. 7a,b, 1859.
Hustedia meekana Shumard, GIRTY, U. S. Geol. Surv. Prof. Pap. 58, p. 394, 1909.

Large for the genus, subequal in depth, slightly longer than wide, with an elongate-oval outline and greatest width at or near the middle; biconvex; lateral margins broadly rounded and anterior margin narrowly rounded. Anterior commissure serrate, rectimarginate. Surface costate, costae angular, separated by furrows equal in width and depth to the costae except for the median costa and furrow which are slightly larger than their fellows. Usually marked by 9 costae on brachial valve and 10 on pedicle valve. Shell substance punctate.

Pedicle valve gently to moderately convex in lateral profile; very gently convex in anterior profile but with sides abrupt. Median sulcus narrow and deep with a short, angular tongue meeting the enlarged median costa of the opposite valve. Median four costae slightly elevated and forming an indistinct fold. Flanks narrowly rounded and with very steep sides. Beak incurved, moderately long; beak ridges sharply defined and bounding a curved, triangular region formed by the symphytium. Foramen small, round, mesothyrid.

Brachial valve slightly more convex than the pedicle valve in lateral profile and slightly more rounded in anterior profile but with equally steep lateral slopes. Median 3 costae elevated above the others and forming an ill-defined fold. Median costa generally perceptibly depressed below the 2 on each side of it. Median fold meeting opposite fold of pedicle valve at anterior to form a distinct lobe protruding anterior to the flanks. Flanks of brachial valve narrowly rounded, sides almost perpendicular.

Measurements in mm.—Hypotypes: (U.S.N.M. No. 115557b), hinge width 4.4, length 14.4, width 11.2, length of brachial valve 12.3, thickness 9.7, width of fold lobe 7.3; (U.S.N.M. No. 115557c), length 14.9, width 12.9, hinge width 4.3, length of brachial valve 12.3, thickness 10.9?, width of fold lobe 9.1.

Hypotypes.—Figured, U.S.N.M. Nos. 115557b,c; unfigured, U.S.N.M. Nos. 115557a, 115558, I.G.M.

Horizon and locality.—*Spiriferellina* zone, loc. 806b, 806d', 806f, 806g, 806h², 806s, 806w, 806y; *Leiorhynchoidea-Cancrinella* zone, loc. 806i.

Discussion.—None of the specimens in the collections from the Monos Hills is exfoliated, consequently the "lirae" occurring in the

troughs between the plications as reported by Girty, are not revealed. The Monos specimens however agree well with the published descriptions and figures of *H. meekana.* The number and arrangment of the plications are like these features in specimens described by Girty, King, and Cloud. The Monos specimens are very close to those figured by King from the Word formation of the Glass Mountains (1930, pl. 42, figs. 38a-38c) but attain a somewhat larger size. This is true also of the specimens figured by Cloud from Las Delicias.

HUSTEDIA MEEKANA PLICATELLA Cooper, new subspecies

Plate 20C, figures 6-15

Shell of about medium size for the genus and species, longer than wide and with longitudinally suboval outline; lateral margins broadly rounded, anterior margin broadly nasute. Surface costate, costae angular and separated by angular furrows of equal size. Costae numbering 14 on the pedicle valve and 13 on the brachial valve.

Pedicle valve with profiles like those of the species and with median 4 costae elevated above the flanks to form a low fold. Median furrow the deepest but tongue not much lengthened. Brachial valve with indistinct fold of 3 costae elevated slightly above the flanks. Anterior lobe formed by folds not extending far anteriorly.

Interior not known.

Measurements in mm.—Holotype, length 14.6, width 11.3, hinge width 3.8, length of brachial valve 12.2, thickness 9.6, width of fold lobe 7.2; paratype (U.S.N.M. No. 115560a), length 13.1, width 11.6, hinge width 3.6, length of brachial valve 10.8, thickness 8.3, width of fold lobe 5 plus.

Types.—Holotype, U.S.N.M. No. 115559; figured paratype, U.S.N.M. No. 115560a; unfigured paratype, U.S.N.M. No. 115560b.

Horizon and locality.—Fairly common in the *Leiorhynchoidea-Cancrinella* zone, loc. 806i.

Discussion.—This variety differs from the species *H. meekana,* occurring higher in the *Spiriferellina* zone, in the possession of somewhat more angular costae, a narrower hinge, more numerous and more crowded costae, a less lobate anterior margin and less flaring flanks. It will be noticed that the measurements of the holotype of the subspecies are almost identical to those of the figured specimen of *H. meekana* (Shumard), yet the subspecies has more numerous costae and therefore a different disposition of the costae although the basic pattern of *H. meekana* is preserved. The narrower hinge also lends the specimen a much more slender appearance although the measurements are almost identical to those of *H. meekana.*

HUSTEDIA ELONGATA Cooper, new species

Plate 20B, figures 4, 5

Shell of about medium size for the genus, elongate-oval, with the length about 1⅗ times the width. Lateral margins very gently rounded; anterior margin narrowly rounded. Surface costate; costae numbering 11 on the brachial valve, narrowly rounded, crowded.

Pedicle valve not well preserved but flanks narrow and steep, the beak short and incurved. Hinge narrow.

Brachial valve with narrow swollen umbo forming most convex part in lateral profile; anterior profile narrowly convex. Median 5 costae forming a low, slightly rounded fold protruding anteriorly from the flanks slightly. Median 3 costae a little more crowded and slightly elevated above the lateral 2 of the fold. Flanks very narrow, rounded and nearly vertical.

Measurements in mm.—Holotype, length 15.1, width 9.0, hinge width 3.0, length of brachial valve 12.9, thickness ?, width of fold lobe 7.2.

Holotype.—U.S.N.M. No. 115556.

Horizon and locality.—Upper part of *Spiriferellina* zone, loc. 806d.

Discussion.—This species differs from *H. meekana* in its narrowly compressed, elongate-oval outline, the crowded costae, and the fold consisting of 5 costae.

PUNCTOSPIRIFER CONVEXUS Cooper, new species

Plate 21B, figures 7-12

Shell fairly large for the genus, suboval in outline and with the length and width about equal. Posterior margins gently concave, lateral margins gently curved; anterior margin medianly emarginate. Anterior commissure uniplicate. Surface costate, flanks marked by six costae. Costae marked by regular zigzag lamellae slightly less than a millimeter apart. Entire surface very finely punctate.

Pedicle valve fairly strongly convex in lateral profile with the umbonal region having the greatest convexity. Anterior profile broadly convex. Umbonal region full and extending posterior to the posterior margin. Sulcus originating at the beak, fairly deep, broadly U-shaped in section and extended anteriorly into a long bluntly pointed tongue. Costae bounding the sulcus slightly elevated above the others; flanks narrowly convex and with steep slopes to the margins. Interarea long, gently curved; beak strongly incurved. Delthyrium elongate, open.

Brachial valve fairly strongly convex in lateral profile with the

greatest curvature in the posterior half. Fold narrowly rounded, widening gradually anteriorly from the beak but only attaining a little more than a third the width of the valve. Fold fairly strongly elevated above swollen and convex flanks. Slopes to margins steep. Interarea short, curved, with the small beak overhanging the delthyrium.

Interior unknown.

Measurements in mm.—Holotype, length 24.3, midwidth 24.7, hinge width (based on measured half width of 10.5) 21.0, length of brachial valve 17.9, thickness 19.6, width of fold 8.8; paratype (I.G.M.), length 20 plus, midwidth 23.0?, hinge width 17.9, length of brachial valve 16.9, thickness 15.5, width of fold 7.4.

Types.—Holotype, U.S.N.M. No. 115495; unfigured paratype, I.G.M.

Horizon and locality.—Upper *Leiorhynchoidea-Cancrinella* zone, loc. 806i.

Discussion.—This species is best recognized by its strongly convex valves with their zigzag, distant lamellae and the numerous very fine punctations on the outside of the shell. In its ornamentation this species belongs to the group of *Punctospirifer billingsi* but this is a much smaller form.

SPIRIFERELLINA LAXA (Girty)

Plate 21A, figures 1-6

Spiriferina laxa GIRTY, U. S. Geol. Surv. Prof. Pap. 58, p. 377, pl. 21, figs. 3-3b, 1909.

Spiriferina haarmanni HAACK, Zeitschr. Deutsch. Geol. Ges., vol. 66, Abh., Heft 4, p. 492, pl. 38, figs. 7a-c, 1914.

Spiriferina laxa Girty, R. E. KING, Univ. Texas Bull. 3042, p. 122, pl. 42, figs. 7-11, 1930.

"Spiriferina" laxa Girty, CLOUD, Geol, Soc. Amer. Spec. Pap. 52, p. 63, 1944.

Shell of about medium size for the genus, slightly wider than long, with the hinge forming the widest part. Somewhat rhomboidal in outline with straight posterior margin and inwardly sloping but gently convex lateral margins. Anterior nasute. Anterior commissure strongly uniplicate. Surface costate, with four costae marking the flanks, the fourth costa very small. Surface marked by coarse, distant punctae.

Pedicle valve gently convex in lateral profile and broadly convex in anterior profile. Sulcus originating at the beak, deepening and widening anteriorly but never becoming wider than the costae immediately bounding it. Flanks flatly convex, somewhat flattened at the cardinal extremities. Interarea long, gently curved; beak incurved gently.

Brachial valve unequally convex in lateral profile, the median por-

tion moderately convex, the umbonal region flattened and the anterior part gently convex. Anterior profile forming a broad triangle with the fold at the center. Fold originating at the beak, narrow and quite strongly elevated above the surrounding flanks, which are flattened in profile with gentle slopes to the margins. Interarea moderately long, narrowly curved.

Interior of the pedicle valve with stout median septum that partially fills the delthyrial cavity.

Measurements in mm.—Hypotype (U.S.N.M. No. 115490), length 16.0, midwidth 16.3, hinge width (based on half width of 9.8) 19.6, length of brachial valve 12.2, width of fold 4.2.

Hypotypes.—U.S.N.M. No. 115490, I.G.M.

Horizon and locality.—*Dictyoclostus* zone, loc. 806k, 806k'; *Leiorhynchoidea-Cancrinella* zone, loc. 806i.

Discussion.—Three specimens are referred to this species, two of them probably the young of the larger one. These specimens agree in most respects with specific descriptions of *S. laxa* and *S. haarmanni* which R. E. King has demonstrated are synonyms. Reference to *Spiriferellina* is based on form and ornamentation. This species is elsewhere reported from the Word formation in the Glass Mountains of Texas and from the Permian area of Las Delicias, Coahuila.

SPIRIFERELLINA SONORENSIS Cooper, new species

Plate 21C, figures 13-27; plate 22D, figures 26-29

Shell large for the genus, width almost twice the length; cardinal extremities strongly mucronate; lateral margins slightly concave to straight, sloping medially; anterior margin truncate. Anterior commissure strongly uniplicate. Surface costate, costae broadly subangular, separated by angular furrows of about the same width as the costae. Fold with a secondary costa on each side at the anterior half; sulcus with 2 secondary costae and often a third median one. Flanks marked by 4 to 8 costae, the last 4 of which are fine, faint or poorly developed. Shell substance coarsely but densely punctate. Zigzag growth lamellae irregular. Large papillae scattered over the surface.

Pedicle valve evenly convex in lateral profile and quite evenly but broadly convex in anterior profile. Umbonal region full, extending posteriorly beyond the posterior margin. Sulcus originating on the umbo, deepening and widening anteriorly to the front margin. Sulcus moderately deep, narrow, with 1, 2, or 3 costae appearing near the middle and extending to the anterior margin. Flanks gently convex; cardinal extremities flattened and usually extended laterally into long

points. Tongue short, acutely pointed. Beak strongly incurved and overhanging the moderately wide delthyrium.

Brachial valve in lateral profile flatly to moderately convex anterior to the umbo which is strongly curved. Anterior profile broadly convex. Fold narrowly rounded and elevated strongly above the flanks with a secondary plication developed on each side from the middle of the valve to the anterior margin. Flanks gently convex near the fold but becoming gently concave posterolaterally toward the cardinal extremities. Umbonal region curved and protruding slightly posterior to the posterior margin. Beak small, overhanging the delthyrium.

Interior of pedicle valve with well-developed apical callosity, usually not flush with the delthyrial edge but sunken below it. Median ridge strong, rising anteriorly to a sharp crest near the middle and sloping abruptly anteriorly from the crest. Diductor scars long, moderately deeply sunk in the umbonal cavity and extending anterior to the ends of the dental plates. Teeth slender, buttressed by short but thick dental plates.

Interior of brachial valve with small, stout crural bases having strong socket ridges and deep sockets. Cardinal process with elongate myophore buttressed by callus. Median ridge absent. Descending lamellae of spire reaching the middle of the valve; jugum extending at right angles from the descending lamellae toward the pedicle valve, its end turned abruptly in a posteropedicle direction.

Measurements in mm.—Holotype, length 21.6, width 51.2 equals hinge width (based on measured half-width of 25.6), midwidth 32.6, length of brachial valve 17.6, thickness 16.3, width of fold 8.1.

Types.—Holotype, U.S.N.M. No. 115485; figured paratypes, U.S.N.M. Nos. 115486, 115487a-c, 115488a,b, 115489, I.G.M.

Horizon and locality.—Rare in the *Composita* zone, loc. 806c, 806h; rare in *Dictyoclostus* zone, loc. 806k, 806k′, 806p, 806x; common in the *Spiriferellina* zone, loc. 806b, 806d, 806d′, 806f, 806s.

Discussion.—In the field this species was at first mistaken for *S. pulchra* Meek which is abundant in the Phosphoria formation in Wyoming, Idaho, and Nevada. Comparison with the type specimen of the latter species made it clear that the Mexican form is totally different. The Mexican specimens are characterized by their laterally extended and often mucronate form and the accessory costae appearing on the fold and in the sulcus.

Compared with *S. pulchra* the Mexican species is more strongly costate with broader and less numerous costae on the flanks. The sulcus of *S. pulchra* is broader and somewhat deeper than that of *S.*

sonorensis and is entirely without any trace of plication either on the sides of the sulcus or in the trough. The same may be said of the fold which in *S. pulchra* is somewhat wider than that of the Mexican species and is without any plication on its sides. Another distinction between the two species is in the ornamentation. Two specimens of the Mexican species preserve coarse pustules on the surface but the dozen specimens of *S. pulchra* in the U. S. National Museum preserve no such ornament.

HETERELASMA CONTRERASI Cooper, new species

Plate 22F, figures 30-45; plate 23A, figures 1-3

Of usual size for the genus, longitudinally elliptical in outline with the length greater than the width. Posterior margin a broad curve; lateral margins gently rounded; anterior margin narrowly rounded to subtruncate. Anterior commissure strongly uniplicate. Surface marked by growth lines and growth varices only. Shell substance finely punctate.

Pedicle valve shallow, strongly curved in lateral profile with the greatest curvature located in the posterior and umbonal regions; anterior profile a very broad U. Umbonal region flattened to gently concave, the concavity extending anteriorly into a broad sulcus that deepens anteriorly. Anterior quarter extended toward the brachial valve in a long, narrow tongue. Beak strongly incurved, overhanging the umbo of the brachial valve. Foramen small, round, mesothyrid. Beak ridges strong.

Brachial valve gently and evenly convex in lateral profile; very narrowly convex and with steep, flat sides in anterior profile. Brachial valve much deeper than the pedicle valve, with median region swollen into a narrow fold, sharply rounded or flattened depending on age. Sides nearly flat, descending steeply to the margins. Umbo narrowly swollen; beak incurved, small.

Interior of pedicle valve with well-developed, subparallel dental plates, and a long, low, sharp median septum extending nearly the full length of the valve. Musculature unknown.

Brachial valve with short, undivided hinge plate; median septum absent; loop long, cryptonelliform, with descending processes flaring laterally in a broad curve and the transverse ribbon forming a narrow posteriorly directed curve.

Measurements in mm.—Holotype, length 14.0, width 10.6, thickness 9.4, length of brachial valve 11.0, width of fold at anterior 6.0; paratypes: (U.S.N.M. No. 115508), length 14.6, width 12.0, thickness 8.4,

length of brachial valve 12.3, width of fold at anterior 7.0; (I.G.M.), length 14.6, width 10.3, thickness 7.7, length of brachial valve 12.4, width of fold at anterior 5.0.

Types.—Holotype, U.S.N.M. No. 115507; figured paratypes, U.S.N.M. Nos. 115508, 115509, I.G.M.

Horizon and locality.—Confined to the lower part of the *Spiriferellina* zone, loc. 806b, 806d′, 806f, 806g, $806h^2$, 806w.

Discussion.—The peculiar form, longitudinally elliptical outline, deeply sulcate pedicle valve and narrowly folded brachial valve make this one of the most distinctive species occurring in the Monos formation.

Heterelasma shumardianum Girty is the only other species of this genus so far described although it occurs at several levels in the Glass Mountains of Texas. Girty's species has never been well understood and the loop was unknown until the writer was fortunate in securing a perfect loop in a specimen etched out of a piece of Word limestone. This cryptonelliform loop and the fragmentary one preserved in one of the Monos specimens confirms this fundamental feature of *Heterelasma.*

Heterelasma contrerasi differs from *H. shumardianum* in a somewhat larger size, a more shouldered appearance and in lacking the distinct but short sulcus on the brachial valve which is such an important feature of the Texas species.

Named in honor of Prof. Francisco Contreras of the Instituto Geológico de México.

HETERELASMA species

Plate 22E, figure 25

The illustration of the loop of *Heterelasma* is introduced here to supplement the partial structures figured for *H. contrerasi.*

Figured specimen.—U.S.N.M. No. 123297.

Horizon and locality.—Word formation (lower part of limestone No. 3), 4 miles northeast of Hess Ranch, Hess Canyon Quadrangle, Texas.

Genus GLOSSOTHYROPSIS Girty

This genus was erected by Girty to care for the species *Cryptacanthia ? robusta* which differed from *Cryptacanthia* in possessing a median septum. The poor preservation of Girty's specimen has left many features of *Glossothyropsis* in doubt. Some of these uncertain characters are definitely revealed in the specimens from the Monos Hills and it is now possible to prepare a better definition of the genus.

Glossothyropsis.—Terebratuloid brachiopods, with strongly sulcate anterior commissure. Foramen mesothyrid. Interior of pedicle valve with strong dental plates; brachial interior with strong median septum, undivided hinge plate and long, cryptonelliform loop.

GLOSSOTHYROPSIS MAGNA Cooper, new species

Plate 23B, figures 4-26

Shell large for the genus, length and width nearly equal, or with the length slightly greater than the width. Outline subpentagonal. Posterior margins slightly convex; posterolateral extremities broadly to narrowly rounded and lending a distinct shoulder to the shell; lateral margins nearly straight to gently convex, sloping toward the middle; anterior margin nearly straight to deeply reentrant. Anterior commissure deeply sulcate. Surface without any other ornament than growth lines. Shell substance finely punctate.

Pedicle valve unevenly convex in lateral profile, the median region gently convex but the anterior and posterior quarters moderately to strongly convex. Anterior profile narrowly convex with rounded to flattened crest and steeply sloping sides. Umbonal region narrowly swollen and extended forward as a rapidly widening fold. Anterior to middle of fold often sulcate; sulcus shallow and, where pronounced, indenting the anterior margin, and separated from the flanks by the cleft fold which forms narrowly rounded bounding plicae. Flanks steep-sided, gently concave. Beak ridges prominent and extending anteriorly as a narrow fold to the rounded lateral shoulder. Beak erect to strongly incurved, overhanging the umbo of the pedicle valve. Foramen small, mesothyrid; deltidial plates forming a symphytium.

Brachial valve shallower than the pedicle valve, gently convex in lateral profile with an abrupt curvature toward the pedicle valve in the anterior quarter. Anterior profile broadly convex, narrowly sulcate medially and with plicae bounding sulcus narrow. Umbonal region slightly swollen. Sulcus originating at varying distances from the beak but usually 3 to 4 mm. Sulcus deepening and widening gradually anteriorly, broadly U-shaped in profile. Flanks bounding sulcus gently convex in posterior but narrowing and becoming more convex anteriorly. Tongue short and with truncated extremity.

Interior of pedicle valve with moderately long, slightly divergent dental plates; musculature unknown. Interior of brachial valve with moderately long and well-elevated, narrow median septum; hinge plate undivided (?), anchylosed with the expanded median septum

at the posterior. Loop long, like that of *Cryptonella.* Musculature unknown.

Measurements in mm.—Holotype, length 20.5, width 19.8, length of brachial valve 17.7, thickness 12.8, width of fold 12.0, width of sulcus of brachial valve ca. 4.5, width of sulcus in fold ca. 8.0; paratypes: (U.S.N.M. No. 115527), length 20.5, width (partially restored) 17.8, length of brachial valve 17.6, thickness 11.8, width of pedicle fold 10.5, width of sulcus of brachial valve 6.5; (U.S.N.M. No. 115529), length 20.9, width 17.0, thickness 13.7, width of pedicle fold 10.0, width of sulcus of brachial valve 6.0, width of sulcus in fold 2.5; (U.S.N.M. No. 115531b), length 14.6, width 12.8, thickness 8.4, width of sulcus of brachial valve 5.2.

Types.—Holotype, U.S.N.M. No. 115526; figured paratypes, U.S.N.M. Nos. 115527-115529, 115530a-c, 115531a,b; unfigured paratype, I.G.M.

Horizon and locality.—Common in the *Composita* zone, loc. 806c, 806g′, 806h; rare in the *Spiriferellina* zone, loc. 806f, 806g, 806h², 806w, 806y; rare in the *Leiorhynchoidea-Cancrinella* zone, loc. 806i.

Discussion.—The only known comparable species is *Glossothyropsis robusta* Girty which is a much smaller species having a subcircular outline, proportionately more strongly convex pedicle valve, and more convex brachial valve.

DIELASMA FLORESI Cooper, new species

Plate 22C, figures 12-24

Shell of about medium size for the genus, longitudinally oval to subpentagonal in outline with the width equal to about two-thirds the length. Greatest width at or near the middle; greatest thickness at about the middle. Valves subequal in depth. Anterior commissure narrowly uniplicate. Surface without any other ornament than growth lines and growth varices.

Pedicle valve moderately and evenly curved in lateral profile; anterior profile broadly and gently convex. Umbonal region narrowly swollen and convex; median region gently swollen; median sulcus originating as a faint, shallow, narrow groove in the median region and extending anteriorly to the front margin, widening and deepening anteriorly. Sulcus deepest at the anterior margin and forming a faint, narrow subangular tongue. Flanks bounding sulcus well rounded and with steep slopes. Foramen large, suboval, strongly labiate.

Brachial valve with an almost straight, barely perceptibly convex lateral profile, but with a moderately strongly curved anterior profile.

Umbonal region somewhat narrowly convex, the narrowed portion extending to the small beak. Median region gently convex and with faintly defined fold in the anterior portion. Sides gently convex and with moderately steep slopes to the lateral margins.

Interior of pedicle valve with short, strong dental plates separated from the lateral walls by very narrow umbonal cavities. Brachial valve with moderately deep notothyrial cavity bounded by short plates supporting the crural bases. Length of loop unknown.

Measurements in mm.—Holotype, length 21.3, width 14.7, thickness 10.8; paratype (I.G.M.), length 23.8, width 17.3, thickness 12.0.

Types.—Holotype, U.S.N.M. No. 115553; figured paratypes, U.S.N.M. No. 115555, I.G.M.; unfigured paratype, U.S.N.M. No. 115554.

Horizon and locality.—Rare in the *Spiriferellina* zone, 806f, 806g.

Discussion.—This species is characterized by the nearly plane lateral profile of the brachial valve, the shouldered outline in brachial view, and the deeply sulcate anterior half of the valve. The species is most similar to *D. prolongatum* Girty but differs in the more pentagonal outline, and much shorter and shallower sulcus of the pedicle valve.

Named in honor of Dr. Teodoro Flores, director, Instituto Geológico de México.

DIELASMA cf. D. PROLONGATUM Girty

Plate 22A, figures 1-6

Dielasma prolongatum Girty, U. S. Geol. Surv. Prof. Pap. 58, p. 331, pl. 16, figs. 5-5c, 1909.

Shell of medium size for the genus, longer than wide with slender longitudinally ovate form. Valves unequally convex, the pedicle valve having the greater convexity and consequently the greater depth. Anterior commissure uniplicate. Greatest width slightly anterior to the middle. Sides moderately rounded; anterior margin truncate. Surface smooth; shell substance punctate.

Pedicle valve strongly convex in lateral view with the greatest convexity located in the median region. Anterior profile gently convex medianly but with steep lateral slopes. Umbonal region elongated and narrowly convex; median region moderately and somewhat narrowly convex and with the origin of a faint median sulcus. Umbonal slopes steep and rounded. Sulcus shallow and narrow, producing a short, bluntly pointed tongue at the anterior. Anterolateral areas convex and with steep slopes. Foramen large, longitudinally elliptical, strongly labiate.

Brachial valve almost flat in lateral profile, but strongly arched in anterior profile. Beak and umbonal region elongated and narrow. Median region narrowly swollen, the swelling continued anteriorly as a low, poorly defined fold that plicates the front margin. Lateral and umbonal slopes moderately long and moderately steep.

Interior unknown.

Measurements in mm.—Hypotype (U.S.N.M. No. 115551a), length 20.5, width 13.3, length of brachial valve ca. 17.5, thickness 10.5.

Hypotypes.—U.S.N.M. Nos. 115551a,b.

Horizon and locality.—*Spiriferellina* zone, loc. 806d′.

Discussion.—Only two specimens of this species were found. These agree best with *D. prolongatum* Girty. Agreement with Girty's species is to be seen in the oval form which lacks any suggestion of the shoulders occurring in *D. floresi.* The folding is similar to that in both species but the sulcus of the type specimen of *D. prolongatum* seems to be broader, deeper, and longer. The sulcus of the Mexican specimens extends to the middle of the valve but is never so deep, possibly because the specimens are somewhat younger examples than those illustrated by Girty.

DIELASMA cf. D. SPATULATUM Girty

Plate 22B, figures 7-11

Dielasma spatulatum Girty, U. S. Geol. Surv. Prof. Pap. 58, p. 330, pl. 16, figs. 3-4c, 1909.

Shell of medium size for the genus, pedicle valve deeper than the brachial, longer than wide and with the greatest width in the anterior portion. Anterior commissure broadly uniplicate. Surface smooth.

Pedicle valve somewhat unevenly convex in lateral profile with the greatest convexity in the posterior half. Anterior profile very broadly and gently convex. Apical region fairly broad; umbonal region moderately swollen with narrowly rounded, steep umbonal slopes. Median region gently convex but anterior flattened to form a broad and very ill-defined sulcate portion. Beak small, incurved, and overhanging the brachial umbo; foramen of moderate size, elliptical, strongly labiate.

Brachial valve just perceptibly convex in lateral profile but moderately strongly arched in anterior profile. Umbonal area moderately swollen, the swelling extending anteriorly through the median and anterior portions of the valve to the front margin which is slightly elevated into a low, poorly defined fold. Umbonal slopes steep but lateral and anterior slopes fairly gentle.

Interior unknown.

Measurements in mm.—Figured specimen (U.S.N.M. No. 115552), length 20, greatest width (based on half measure of 13.4) 26.8, thickness 8.9.

Hypotype.—U.S.N.M. No. 115552.

Horizon and locality.—*Leiorhynchoidea-Cancrinella* zone, loc. 806i.

Discussion.—The slender profile and broadly spatulate form of the single specimen found determined its reference to Girty's species. The Mexican specimen differs from Girty's illustrated types in having a less well-defined fold on the pedicle valve but, inasmuch as the specimen has suffered some crushing, its true features may have been obliterated.

PELECYPODA

Invertebrate fossils, except brachiopods, are rare in the Permian beds northeast of El Antimonio. Only one locality, 806i, has yielded more than one or two species. Most of the specimens show no trace of the hinges and are difficult to identfy as to genus. Nevertheless the following have been seen.

Pleurophorus species is a small form seen at locality 806-o. The specimen may be a juvenile. It is too poorly preserved to be sure of that fact or its actual identity except that it has the elongated form of this genus.

Nucula, 3 species.—Nine specimens are referred to three species of *Nucula.* All the specimens are too poorly preserved for description. They are, moreover, all small and triangular forms. One species, the smallest one, was taken from the *Spiriferellina* locality 806f; the other two species come from the *Leiorhynchoidea-Cancrinella* zone at locality 806i. One specimen from the latter locality represents a narrowly triangular species and the other seven specimens represent a broadly triangular form.

Myalina.—A small or juvenile species was taken from the *Spiriferellina* zone at locality 806f.

Cyrtorostra.—A small but poorly preserved specimen of this genus was taken from the *Composita* zone but the exact locality is not known.

Pectinoid pelecypods.—Two specimens clearly having affinities with the Paleozoic pectenoids were taken, one, *Aviculopecten montpelierensis* Girty, from the *Leiorhynchoidea-Cancrinella* zone, locality 806i, and another from the *Spiriferellina* zone at 806f.

NUCULANA OBESA White

Plate 23D, figures 29-32

Nuculana obesa White, U. S. Geol. and Geogr. Surv. Terr. Bull. 5, p. 216, 1879; 12th Ann. Rep. U. S. Geol. and Geogr. Surv. Terr. (1878), pt. 1, p. 136, pl. 34, figs. 2a-c, 1883. (Adv. print, 1880.)

Leda obesa (White) Girty, U. S. Geol. Surv. Bull. 389, p. 76, 1909; U. S. Geol. Surv. Bull. 436, p. 40, pl. 4, figs. 7-8, 1910.—C. C. Branson, Univ. Missouri Studies Quart., vol. 5, No. 2, p. 43, pl. 10, figs. 21, 22, 1930.

Large for the genus, length about $1\frac{1}{2}$ times the height; outline subtriangular, anterior margin narrowly rounded; ventral margin gently convex; posterior produced, bluntly pointed. Beaks small, closely appressed, opisthogyrate; umbo swollen; umbonal and anterior slopes convex; posterior gently convex; posterior slopes gentle; lunule large. Surface marked by rounded, concentric lines separated by narrower furrows, about 7 in 5 mm. on the median slopes.

Measurements in mm.—Hypotype (U.S.N.M. No. 115580a), length 32.0 ? (restored), height 19.7, thickness 16.8; hypotype (U.S.N.M. No. 115580b), length 11.9, height 8.4, thickness 7.0.

Hypotypes.—Figured, U.S.N.M. No. 115580a; unfigured, U.S.N.M. No. 115580b.

Horizon and locality.—*Leiorhynchoidea-Cancrinella* zone, loc. 806i.

PLEUROPHORUS SONORENSIS Cooper, new species

Plate 24B, figures 10-18

Shell of about medium size for the genus, amygdaloidal to subrectangular in outline; length slightly more than twice the height; somewhat narrower anteriorly than posteriorly; beaks small, directed posteriorly, closely appressed. Lunule long and narrow, about three-fifths the length; escutcheon small, deep. Umbones small, slightly swollen; umbonal slopes strongly swollen in the median portion but flattened ventrally. Posterior slope long and gentle; umbonal ridge strongly rounded, extending to the posterior slope. Posterior margin narrowly rounded ventrally but gently rounded posterodorsally. Anterior margin slightly nasute ventrally; ventral margin nearly straight; hinge line gently curved.

Surface marked by concentric lines and varices of growth.

Measurements in mm.—Holotype, length 33.8, height 14.8, thickness 12.9; paratype (U.S.N.M. No. 115576a), length 43.0 (restored), height 20.0, thickness 16.8.

Types.—Holotype, U.S.N.M. No. 115575; figured paratype, U.S.N.M. No. 115576a; unfigured paratype, U.S.N.M. No. 115576b.

Horizon and locality.—*Leiorhynchoidea-Cancrinella* zone, loc. 806i.

Discussion.—*Pleurophorus sonorensis* is a large species characterized by its rounded extremities and convex valves. Of North American described species it approaches *P. mexicanus* Girty in size but differs in having a less-produced anterior and rounded posterior extremity. *Pleurophorus pinnaformis* Branson is a large species but is somewhat smaller than *P. sonorensis* and has a more pointed posterior extremity and less-convex valves.

SCHIZODUS PARVULUS Cooper, new species

Plate 24A, figures 1-9

Shell small for the genus, thin-shelled, narrow, subtriangular in outline. Ventral margin gently convex; anteroventral extremity very narrowly rounded; anterior margin gently convex; posterior margin narrowly rounded; hinge line arcuate. Beaks small, directed anteriorly, closely appressed. Umbonal region somewhat narrowly swollen; median region gently swollen. Anterior slopes steep and concave; terminating in a ridge at valve junction. Posterior slopes gentle.

Measurements in mm.—Holotype, length 13.4, height 10.1, thickness 5.2, umbonal angle 120°; paratype (U.S.N.M. No. 115584a), length 12.3, height 7.7, thickness 5.5, umbonal angle 110°.

Types.—Holotype, U.S.N.M. No. 115583; figured paratype, U.S.N.M. No. 115584a; unfigured paratypes, U.S.N.M. Nos. 115584b-h.

Horizon and locality.—*Anidanthus* zone, loc. 806m, 806n, 806-o.

Discussion.—*Schizodus parvulus* is most notable for its elongate triangular outline and small size. *Schizodus ferrieri* Girty from the Phosphoria formation is larger and less elongated. *Schizodus concinnus* Branson from the same formation is a small species but it is more equilateral and has a more strongly rounded ventral margin than the Mexican species.

SCAPHOPODA

PLAGIOGLYPTA CANNA (White)

Plate 24C, figures 19, 20

Dentalium canna WHITE, U. S. Geogr. Surv. west of 100th Meridian, Preliminary Report, p. 23, 1874; idem, Final Report, vol. 4, pt. 1, p. 156, pl. 12, figs. 6a-b, 1877.

Plagioglypta canna (White) GIRTY, U. S. Geol. Surv. Prof. Pap. 58, p. 450, pl. 23, figs. 11-13, 1909; U. S. Geol. Surv. Bull. 389, p. 95, pl. 11, fig. 11, 1909; U. S. Geol. Surv. Bull. 436, p. 44, pl. 6, fig. 14, 1910.—E. B. BRANSON,

Journ. Geol., vol. 24, p. 657, pl. 3, fig. 13, 1916.—C. C. Branson, Univ. Missouri Studies Quart., vol. 5, No. 2, p. 58, pl. 15, fig. 6, 1930.

Shell fairly large; shell substance moderately thick. Cross section circular. Shell a long, tapering cone very slightly curved. Surface marked by concentric, oblique undulations of growth. Length of specimen 72 mm., large diameter 10.0 mm., small diameter 4.3 mm.

Figured specimen.—U.S.N.M. No. 116637.

Horizon and locality.—*Anidanthus* zone, loc. 806m; *Dictyoclostus* zone, loc. 806m'.

CEPHALOPODA

By ARTHUR K. MILLER

University of Iowa

(PLATE 24D)

WAAGENOCERAS DIENERI Böse

Plate 24D, figures 21-23

Waagenoceras Dieneri BÖSE, Univ. Texas Bull. 1762, pp. 18, 33, 127, 171-176, pl. 10, figs. 28-31; pl. 11, figs. 1-27, 1919.—DIENER, Fossilium catalogus, I, Animalia, pt. 14, p. 26, 1921.

Waagenoceras dieneri BÖSE, Amer. Journ. Sci., ser. 5, vol. 1, pp. 190, 192, 1921.—P. B. KING, Univ. Texas Bull. 3038, pp. 71, 72, 131, 139, 1930.—R. E. KING, Univ. Texas Bull. 3042, pp. 10, 18, 1930.— P. B. KING, Geol. Soc. Amer., Bull., vol. 45, p. 735, 1934.— PLUMMER and SCOTT, Univ. Texas Bull. 3701, pp. 25, 27, 32, 156, 157-158, 160, 161, 163, 397, 398, 399, 400, pl. 39, figs. 5-8, 1937.—MILLER and FURNISH, Geol. Soc. Amer. Spec. Pap. 26, pp. 11, 14, 17, 18, 21, 157, 158, 160, 161, 167, 168, 170-173, pl. 39, figs. 1-6; pl. 43, figs. 4-7; pl. 44, fig. 3, 1940.— P. B. KING, Amer. Assoc. Petrol. Geol., Bull., vol. 26, pp. 601, 604, 1942.—MILLER and UNKLESBAY, Journ. Paleontol., vol. 17, pp. 17, 24-25, pl. 5, fig. 2, 1943.—MILLER, Geol. Soc. Amer. Spec. Pap. 52, pp. 72, 73, 74, 109, 111-114, pl. 25, fig. 7; pl. 31, figs. 6-12; pl. 32, figs. 1-8; pl. 33, figs. 1-7; pl. 34, figs. 1-9, 1944; Journ. Paleontol., vol. 19, pp. 20-21, 22, pl. 7, figs. 3, 4, 11, 12; pl. 8, fig. 1, 1945.

Waagenoceras dieneri? R. E. KING, Amer. Journ. Sci., ser. 5, vol. 27, pp. 105, 106, 1934.

Waagenoceras richardsoni PLUMMER and SCOTT, Univ. Texas Bull. 3701, pp. 156, 158-160, 161, pl. 39, figs. 9-11, 1937.

Waagenoceras cf. *W. dieneri* HAYASAKA, Nat. Taiwan Univ. Sci. Rep., ser. 1, Acta Geol. Taiwanica, vol. 1, No. 1, pp. 16, 25-26, 35, pl. 2, fig. 5, 1947(?).

The only Permian ammonoid that has so far been described from Sonora is a poorly preserved representative of *Waagenoceras dieneri* Böse from the so-called *Spiriferina* beds northeast of El Antimonio (Miller, 1945, p. 22, pl. 8, fig. 1). A second specimen has been found at the same general horizon at a nearby locality (806g), and it also seems to be referable to *W. dieneri*.

This individual is a completely septate silicified internal mold, which unfortunately does not reveal the nature of the sutures very well. Its maximum diameter measures about 20 mm., and near its adoral end its conch (which is subglobular in shape) is about 11 mm. high and 17 mm. wide. The umbilicus, though deep, is rather small and attains

a maximum diameter of only about 3 mm. The umbilical shoulders are abruptly rounded, and the umbilical walls are very steep. A single transverse constriction is preserved in the adoral part of the specimen, and it is essentially straight and directly transverse.

The septum which forms the adoral end of this specimen and dorsal portions of several septa that adhere to the outer volution show that on each of the lateral zones of the conch the general course of the sutures is distinctly arcuate, being convex orad; the ventral lobe is short, broad, prominently bifid, and digitate; and the dorsal sutures consist of a short, broad, trifid, digitate dorsal lobe and on either side of it six digitate lobes which become progressively smaller toward the umbilicus.

Remarks.—The ascertainable portion of the sutures as well as the general physiognomy of the conch indicate clearly that this specimen belongs in the genus *Waagenoceras* and almost certainly in *W. dieneri* Böse. Representatives of *Waagenoceras* occur in the Sosio beds of Sicily, are rare in the Basleo beds of Timor and the East Tungkuan black shale of Chekiang (central eastern China), and are fairly abundant in the Word, upper and middle Delaware Mountain, and Capitan formations of west Texas and equivalent beds in southwestern Coahuila. The genus is characteristic of the upper part of the Middle Permian. *W. dieneri* was originally described from the Word formation of Texas, and has since been found to occur in the Word and lower Capitan equivalents in the Delaware Mountains of west Texas and the Valle de Las Delicias of southwestern Coahuila. Hayasaka has recently compared a small individual from eastern China to this species but the published data in regard to it do not enable us to determine its specific affinities.

Hypotype.—U.S.N.M. No. 116635.

Horizon and locality.—*Spiriferellina* zone, loc. 806g. The specimen previously described from this same general horizon and locality came from "top of east knob of Mill Hill, San Francisco, 2 km. north-northeast of El Antimonio."

GASTROPODA

By J. BROOKES KNIGHT

United States National Museum

(PLATES 24E, F, G, 25A, B, C)

INTRODUCTION

As the science of paleontology grows more mature it becomes increasingly apparent that to describe and name new species on poor material and new genera on inadequately known species is no real contribution to knowledge. Rather it is a disservice, especially to the taxonomist who cannot deal wisely with inadequately known species and genera and yet must deal with them in some way. They are before him by virtue of the fact that they have been described and named and therefore are presumptively a part of our accumulated knowledge. However, the presumption is false for, paradoxically, all that we truly know of such forms is that we know little or nothing of significance about them.

The requirements of the stratigraphic paleontologist are perhaps less exacting in that he can use for purposes of correlation any phenomena, organic or inorganic, that are found empirically to characterize rocks of some stratigraphic or time unit, whether or not the phenomena are amenable to classification or taxonomic treatment. However, for such workers there is little advantage to the naming of forms that can be recognized with even reasonable assurance only at the original locality, or only when the beds that carry the forms are identified first. Again, when species and genera are described and named on the basis of inadequately known material there is a tendency for some workers to identify them, even though no precise identification is possible, in rocks of other, often far-distant, regions with consequent miscorrelations. These may be disastrous to a correct understanding of stratigraphy. Needless to say, what is said in respect to species and genera based on material inadequate for precise recognition applies also to units based on better material but described and figured inadequately for recognition or for significant taxonomic treatment. Precise work requires adequately described and figured units based on adequate material.

On the other hand, a collection of fossils from beds in a region previously unstudied may tell us much, even though the specimens themselves are too poorly preserved to warrant detailed descriptions or the naming of species. For example, the genera may be recognized even though the species are not, and genera alone may tell a significant story. Again, similarities to known species may appear, and, if handled with caution, the similarities may be suggestive even though they cannot be used as precise identities may.

Such a collection of poor material is that on which this report is based. It comes from a region hitherto little known stratigraphically. The specimens are too poorly preserved, for the most part, to justify specific naming and description and yet several significant genera, both described and undescribed, may be recognized. From these alone one may hazard certain conclusions with more or less confidence.

The collection consists of 17 specimens of gastropods. I am especially grateful to Dr. G. A. Cooper for an opportunity to study these specimens since I am currently engaged in a study of the Permian gastropods of the southwestern United States. The very large collections at my disposal for that study enable me to make comparisons with forms from standard sections in other, better-known regions even though descriptions of the genera and species involved are as yet unpublished.

All the specimens are silicifications, some of them etched free from matrix by acid in the laboratory. Their deficiency in preservation lies in the fact that the specimens may have been worn and abraded before silicification and in any case the mineralization is so coarse that few of the details, such as growth lines or the finer ornamentation, are preserved. Insofar as genera can be determined by gross form alone, most are recognizable, but in a few specimens, where knowledge of the shape of the apertural margin is essential, the lack of growth lines makes precise generic recognition impossible.

I shall identify only one previously described species and shall name no new species. For unpublished genera recognized among my collections for the above-mentioned monograph of Permian gastropods, I shall employ, with a query, the name of some related described genus, using the name in its broadest sense, virtually as though it referred to a family or superfamily. Thus, I shall designate undescribed genera in the Pleurotomariidae (or Pleurotomariacea) as *Pleurotomaria*(?). This procedure will avoid the publication of the more precise but as yet unpublished generic designations as nomina nuda.

SYSTEMATIC DESCRIPTION

EUPHEMITES SUBPAPILLOSUS (White)

Plate 25A, figures 1-8

Bellerophon carbonarius Cox, var. *subpapillosus* White, 1876, U. S. Geol. and Geogr. Surv. Terr., Report on the Geology of the Uinta Mountains, p. 92 (Upper Aubrey group; Beehive Point, Horseshoe Canyon (type locality), near Echo Canyon and near Echo Park, Utah).

Bellerophon subpapillosus White, White, 1879, Bull. U. S. Geol. Surv. Terr., vol. 5, p. 218 ("Carboniferous," Wild Band Pockets, northern Arizona, 15 miles south of Pipe Spring).

Bellerophon subpapillosus White, White, 1880 and 1883, 12th Ann. Rep. U. S. Geol. and Geogr. Surv. Terr., pt. 1, p. 138, pl. 34, fig. 36 ("Upper Carboniferous," northwestern Colorado and northern Arizona.)

Euphemus subpapillosus (White), C. C. Branson, 1930, Univ. Missouri Studies Quart., vol. 5, No. 2, p. 54, pl. 16, figs. 19-21 (top limestone member of the Phosphoria formation, Permian Wind River and Owl Creek Mountains; and phosphate beds of the same formation in the Sublette Range, Wyo.

Rather wide, bellerophontiform gastropods with revolving costae developed on an inductural layer of the shell deposited by the mantle over the outer surface of the shell (the principal diagnostic generic character of *Euphemites*), the costae broken into linear series of nodes on the anterior slope; costae few (8 to 12), coarse, with wide interspaces frequently more numerous through intercalation within the aperture than without; shell thick.

Dimensions

(Estimated, with allowance for imperfections of preservation.)

	Width across aperture mm.	Diameter (sagittal) mm.
Lectotype (U.S.N.M. No. 117995)	18.2	17.0
Largest paratype (U.S.N.M. No. 8234d)	23.0	21.8
Smallest paratype (U.S.N.M. No. 8234c)	14.6	12.7
Largest Mexican specimen (U.S.N.M. No. 116630)	16.9	15.0

Remarks.—The lectotype and paratypes and many other specimens in the U. S. National Museum collections are silicifications, the former broken free from the rock and some of the others etched free by acid. No specimen is very well preserved but all of them together show clearly the character of the species. The Mexican specimens are coarse silicifications, the largest etched free from matrix by acid. Although it might have been difficult to identify the specimens from the literature, a comparison with the types and numerous other specimens in the U. S. National Museum, leaves little doubt of the correctness of the identification.

Comparison.—No species of *Euphemites* in rocks older than Permian is characterized by its costae breaking up into rows of pustules on the anterior slope of the whorl. In the Permian there are several species that have this peculiarity but comparison with them had best await their publication.

Hypodigm.—Eighteen specimens as listed below, and approximately 40 other specimens too poor for certain identification.

Occurrence.—The Mexican specimen (U.S.N.M. No. 116630) was derived from the *Spiriferellina* zone at 806d. Specimens from the United States include White's primary types (the lectotype, U.S.N.M. No. 117995, 2 paratypes figured by White, U.S.N.M. Nos. 8234a, b, and 5 unfigured paratypes, U.S.N.M. Nos. 8234c-g) from Beehive Point, Horseshoe Canyon, Utah, 5 hypotypes (U.S.N.M. Nos. 15207a-e) from Vermillion Creek, Uintah Mountains, Utah, and a small slab (U.S.N.M. No. 15205) with several specimens, and 2 specimens (U.S.N.M. No. 89179) from the Kaibab limestone, Grand Canyon National Park, Ariz. In addition there are about 40 specimens (U.S.N.M. No. 15208) too poor for positive identification from a locality on Ashley Creek, Uintah Mountains, and a slab with a number of poor specimens (U.S.N.M. No. 15204) from north of Well Station, in the Humboldt Mountains of Nevada.

E. subpapillosus appears to characterize beds of Phosphoria (Word age) in the United States.

WARTHIA, species A

Plate 25B, figures 9-12

This species is moderately large for the genus. In other respects it is impossible to describe it so as to differentiate it from other species. Species of *Warthia* being almost without ornamentation of any kind require exceptionally well-preserved specimens, preferably in abundance, for specific discrimination. Although *Warthia* is a genus that characterizes Permian rocks, one of the two species previously described from North America is of late Pennsylvanian age, *Warthia kingi* Moore, 1941. The other, described on the basis of such poor material as to be specifically unrecognizable and probably generically misplaced, is *Warthia americana* Girty, 1909, from the Delaware Mountain formation of the Guadalupe Mountains of Texas. In the collections for the monograph mentioned previously I have beautifully preserved specimens of three species, two from the lower Bone Spring limestone of Leonardian age in the Sierra Diablo and one from Word limestone No. 1 in the Glass Mountains of Texas. The Mexican speci-

mens cannot be identified with any of these three species but in some respects are closer to that from the Word limestone of the Glass mountains.

Figured specimen.—U.S.N.M. No. 116632a.

Horizon and locality.—Highest Permian, loc. 806t.

PLEUROTOMARIA(?), species A

Plate 24E, figure 24

Pleurotomaria (*?*), species A, is represented in the Mexican collections by three poor specimens, all from a single locality. They are merely fillings, or casts, of the interior of the shell. Nevertheless the species appears to belong to an undescribed pleurotomarian genus that yields casts that permit generic recognition with reasonable certainty, at least within the range of its stratigraphic occurrence. Two undescribed species of this genus occur in the Permian of west Texas. One is seemingly confined to rocks of Leonardian age in both the Sierra Diablo and Glass Mountains and the other is known only from Word limestone No. 1 in the Glass Mountains.

Figured specimen.—U.S.N.M. No. 116627a.

Horizon and locality.—*Leiorhynchoidea-Cancrinella* zone, loc. 806i.

PLEUROTOMARIA(?), species B

Plate 24E, figure 25

Pleurotomaria (*?*), species B, is represented by a single specimen, a coarsely silicified and badly weathered shell showing the form and the general nature of the ornamentation. The shell shows a turbinate form with the area above the selenizone well arched. The outer whorl face below the selenizone, which lies at about the middle of the whorl, shows a nearly vertical lateral area just beneath the selenizone, separated from the gently arched base by an obtuse angulation. The selenizone is relatively broad and shows as a gently concave band between two bordering lirae. On the whorls of the spire it falls a short distance above the lower suture. The ornamentation appears to consist of fine revolving lirae, so far as it is preserved. All these features show that the species belongs to an undescribed genus that is represented in the Permian rocks of west Texas by six undescribed species ranging throughout the rocks of Leonardian age and into Word limestone No. 1. In spite of its poor preservation I am inclined to identify the Mexican specimen as belonging to a species occurring in Word limestone No. 1 in the Glass Mountains of Texas.

Figured specimen.—U.S.N.M. No. 116628.

Horizon and locality.—*Leiorhynchoidea-Cancrinella* zone, loc. 806i.

PLEUROTOMARIA(?), species C

The single specimen to which the above tentative designation is given, while very poorly preserved, suggests characteristics that are worthy of mention even though one cannot be certain of them. The form appears to be rather low and flat, almost rotaliform. The upper whorl surface slopes outward and gently downward from the upper suture with very gentle convexity. The outer whorl face, separated from the upper by an obtuse angulation, slopes steeply downward and little, if any, outward. It is separated from the very gently arched base by a second obtuse angulation. What appears to be the selenizone lies at about the middle of the outer whorl face. It is narrow, concave, and bordered above and below by low lirae. The umbilical region seems to be surrounded by a callus. The ornamentation consists of revolving lirae, seemingly finer and more numerous on the base than on the upper surface. Ornamentation other than the selenizone appears to be lacking on the outer whorl face. It is possible that this is a mashed specimen of *Pleurotomaria* (?), species B, but this does not appear to be true. In any case I cannot recognize in the specimen any species or genus with which I am familiar. That it is a pleurotomarian in the broadest sense, seems to be very probable.

Described specimen.—U.S.N.M. No. 116634.

Horizon and locality.—*Spiriferellina* zone, loc. 806d.

OMPHALOTROCHUS(?), species A

Plate 24F, figures 26, 27

The single specimen representing this species is the largest, the most striking, and the best preserved in the collection. It has the form of a flat, based cone with a pleural angle of 55°. The apex is badly abraded and largely missing, and although enough of the base is preserved to show that it is quite flat and narrowly phaneromphalous it, too, is in bad condition. The specimen is about 25 mm. high, its base has a diameter of about 27 mm., on its umbilicus a diameter of about 3 mm. The sides of the whorls slope flatly outward and downward from the upper suture in conformity with the conical shape of the shell for about three-fifths the whorl height. The lower two-fifths is occupied by a raised area, gently concave between two costae, that might be mistaken for a selenizone. The upper of the two costae is the weaker

and the more restrained of the two. The lower costa projects outward more strongly on the whorls of the spire and on the final whorl forms a flange around the base. This raised area, with its bordering costae, forms a conspicuous spiral ribbon winding about the cone of the shell.

Unlike the other specimens of the present collection, this one shows a few growth lines. These are preserved on the flat upper three-fifths of the outer whorl face and, very obscurely, across the raised area. Beginning at the upper suture they curve gently backward and then forward indicating a gentle and broad sinus in the outer lip at this position. Below on the raised band they pass more strongly forward indicating that the lower costa or flange projected rather strongly forward at the base of the aperture. They cannot be followed on the base. There is no ornamentation other than the features mentioned.

This species is referable to an undescribed genus of several undescribed species widely distributed in Leonardian and lower Guadalupian rocks of west Texas. Perhaps because they have not yet been studied sufficiently, I am unable to identify the Mexican specimen with any of the west Texas species although there is no doubt whatever as to the generic consanguinity. The relations of this as yet undescribed genus to *Omphalotrochus* (s.s.) will be discussed elsewhere.

Figured specimen.—U.S.N.M. No. 116625.

Horizon and locality.—*Leiorhynchoidea-Cancrinella* zone, loc. 806i.

STRAPAROLLUS(?), species A

Plate 24G, figures 28-32

This species is represented in the Mexican collection by two very roughly silicified specimens that show little more than the shape. The form is that of a low dome. The whorls are gently flattened above to conform to the contours of the dome. The outer margin of the whorls is low and is in the form of a blunt acute angle. The base of the whorls is flatly arched but bluntly angulated where the steep-sided umbilicus begins. The umbilicus, about as wide as the whorls, is about one-third the diameter of the base of the shell. No traces of ornamentation, if any existed, are preserved on the specimens.

Straparollus (?), species A, is referable to an undescribed genus seemingly represented in the Leonardian Bone Spring limestone of the Sierra Diablo by one species and in the Guadalupian Word limestone No. 1 of the Glass Mountains by another. The present specimens can be identified with neither species.

Figured specimen.—U.S.N.M. No. 116633a.

Horizon and locality.—*Spiriferellina* zone, loc. 806f.

ORTHONYCHIA, species A

Plate 25C, figure 13

This species is represented by a single poorly preserved silicified shell. Save to remark that the species is a typical representative of the genus *Orthonychia* (sometimes placed as a subgenus of *Platyceras*) there is little to say about it.

Orthonychia ranges at least from Devonian to Permian and is represented by many species. These seem to have been coprophagous on crinoids and attached to their host throughout their lifetime. Thus they are strongly affected by their substratum and many species are difficult to identify. Species similar to the one represented by the Mexican specimen are found in the Leonard and Word limestone No. 1. of the Glass Mountains but specific identification would be most hazardous. Certainly the Mexican specimen is larger and has a much thicker shell than those from the Glass Mountains.

Figured specimen.—U.S.N.M. No. 116629.

Horizon and locality.— *Anidanthus* zone, loc. 806m.

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EXPLANATION OF PLATES

PLATE 1

Fig. 1. Mill Hill from the southwest side. The knob on the left is composed of the *Composita zone,* which forms the highest and darkest wall, and the overlying *Spiriferellina* zone. The hill on the right has the same sequence and the saddle between them marks a fault.

Fig. 2. View looking southwest from Mill Hill, showing the largest hill (295 m.) on the left. The saddle divides two sequences of *Composita* and overlying *Spiriferellina* zones as in the preceding. The dark blocks at the base of the slope are composed of *Composita* zone and *Spiriferellina* zone blocks.

PLATE 2

Parafusulina antimonioensis Dunbar, new species........................... 15

Figs. 1, 3. Axial sections of megalospheric shell, holotype specimen, U.S.N.M. No. 123301, × 1 and × 10. The right end of the former is restored by reversing the image of the left end.

Fig. 2. Median axial surface of a young microspheric shell, paratype, U.S.N.M. No. 123302c, × 1.

Fig. 4. Axial section of the middle part of the specimen shown in figure 2, × 10, for comparison with the megalospheric holotype, figure 3.

Fig. 5. Part of a tangential slice of a much larger microspheric shell, paratype, U.S.N.M. No. 123302f, × 10. The cuniculi show well along the middle of the slice.

Figs. 6, 7. Sagittal sections of megalospheric paratypes, U.S.N.M. Nos. 123302d, e, × 10.

Fig. 8. Small bit of a tangential slice of a megalospheric paratype, U.S.N.M. No. 123302h, showing the cuniculi, × 10.

All from the fusuline bed at Moreno house about 2¼ miles north-northeast of El Antimonio, Sonora, loc. 806j.

PLATE 3

Parafusulina antimonioensis Dunbar, new species........................... 15

Fig. 1. Slightly oblique axial section of a paratype, U.S.N.M. No. 123302a, × 10. Owing to the obliquity, the ends are foreshortened and the axial filling is not shown.

Fig. 2. Slightly more than half of a tangential slice of a paratype, U.S.N.M. No. 123302g, × 10, cut close to the axis, showing well the axial filling and the normal profile of the shell. Ink line indicates the middle.

Fig. 3. Well-oriented axial section of half of the largest megalospheric paratype seen, U.S.N.M. No. 123302b, × 10.

All from the fusuline bed about 2¼ miles north-northeast of El Antimonio, Sonora, loc. 806j.

Plate 4

A. *Orbiculoidea,* species 2 22

Figs. 1, 2. Brachial and side views of the inner filling of a large brachial valve, × 1. Figured specimen, I.G.M., loc. 806i.

B. *Derbyia elongata* Cooper, new species 23

Figs. 3, 4. Side and pedicle views of the holotype, U.S.N.M. No. 115589, × 1, loc. 806m.

Figs. 5-7. Well-preserved pedicle valve, paratype, U.S.N.M. No. 115475, × 1. 5, Interior showing long septum; 6, view showing the long interarea; 7, the exterior, × 1. Loc. 806n.

C. *Orbiculoidea,* species 1 21

Fig. 8. Plasticine replica of exterior of an imperfect brachial valve, × 2. Figured specimen, I.G.M., loc. 806f.

D. *Streptorhynchus* species 24

Figs. 9-11. Apical portion of a small pedicle valve, U.S.N.M. No. 115523, × 1. 11, Shows the thick pseudodeltidium; 10, interior showing thick dental ridges. *Dictyoclostus* zone, loc. 806k.

Fig. 12. Interior of a fragmentary specimen with restoration of broken parts, U.S.N.M. No. 115524b. Same zone as above, loc. 806-l.

Fig. 13. Exterior of a large imperfect specimen with probable outline of complete specimen, U.S.N.M. No. 115524a, × 1. Horizon and locality same as above.

Plate 5

Derbyia arellanoi Cooper, new species 22

Fig. 1. Young individual attached by the beak to an imperfect specimen of the productid *Liosotella,* × 1. Larger specimens broke free from their attachment to surfaces to live free on the sea bottom. Paratype, U.S.N.M. No. 115474a, loc. 806n.

Figs. 2, 3. Brachial and posterior views of an imperfect specimen, × 1, a little more advanced in age than the specimen shown in figure 1. Paratype, I.G.M., loc. 806n.

Figs. 4-6. Posterior, side, and pedicle views of a specimen larger than the two preceding ones, × 1, showing a more elongate interarea than the holotype. Paratype, I.G.M., loc. 806n.

Figs. 7, 8. Views of a brachial posterior, paratype, U.S.N.M. No. 115474b, × 1 and × 2, respectively, showing the cardinal process. Loc. 806n.

Figs. 9-12. Side, posterior, pedicle, and brachial views, respectively, of the holotype, U.S.N.M. No. 115473, × 1, loc. 806n.

Plate 6

A. *Marginifera,* species 1 34

Figs. 1-4. Brachial, posterior, anterior, and pedicle views of a fairly well-preserved specimen, U.S.N.M. No. 115562a, × 1, loc. 806k.

Figs. 5-7. Pedicle, posterior, and anterior views of another specimen, U.S.N.M. No. 115563a, × 1, *Dictyoclostus* zone, loc. 806-l.

B. *Chonetes foshagi* Cooper, new species.. 25

Figs. 8-10. Pedicle, side, and brachial views, respectively, × 1, holotype, U.S.N.M. No. 115506, upper part *Cancrinella* zone, loc. 806i.

Figs. 11, 12. Pedicle and brachial views of the holotype, ×2, showing the plicae of the pedicle valve and the broad brachial fold.

C. *Marginifera*, species 2.. 35

Figs. 13, 14. Brachial and side views of a nearly complete specimen, I.G.M., × 1, *Composita* zone, loc. 806r.

Fig. 15. Brachial view of the interior filling of another specimen, U.S.N.M. No. 115564a, showing median ridge, adductor and brachial scars, × 1, *Composita* zone, loc. 806h.

Figs. 16-18. Posterior pedicle and anterior views of another specimen, × 1, horizon and locality same as figure 15.

Fig. 19. Anterior view of a fourth specimen, U.S.N.M. No. 115564b, showing sulcus and costae, × 1, horizon and locality same as figure 15.

Figs. 20-22. Anterior, pedicle, and posterior views of a large imperfect specimen, I.G.M., × 1, horizon and locality same as figure 15.

D. *Chonetes gibberulus* Cooper, new species.. 26

Fig. 23. Brachial view of holotype, U.S.N.M. No. 115504, × 2, showing interareas and folded anterior, *Dictyoclostus* zone, loc. 806-l.

Figs. 24-26. Pedicle, side, and brachial views, respectively, of the holotype, × 1.

Fig. 27. Dorsal view of a somewhat deformed paratype, I.G.M., × 1, *Dictyoclostus* zone, loc. 806k.

E. *Chonetes monosensis* Cooper, new species.. 27

Figs. 28, 29. Brachial and posterior views of the holotype, U.S.N.M. No. 115499, × 2, showing ornamentation and interareas, upper part of *Spiriferellina* zone, loc. 806d.

Figs. 30-32. Brachial, side, and pedicle views of the holotype, × 1.

Fig. 33. Brachial view of a paratype, U.S.N.M. No. 115501, × 1, horizon and locality same as holotype.

Fig. 34. Fragment of a brachial interior showing median ridge, lateral septa and cardinal process, paratype, U.S.N.M. No. 115500, × 2, horizon and locality same as holotype.

Plate 7

A. *Heteralosia mexicana* Cooper, new species.. 28

Figs. 1, 2. Brachial and pedicle views of the holotype, U.S.N.M. No. 115587, × 1, *Spiriferellina* zone, loc. 806f.

Fig. 3. Pedicle view of the holotype, enlarged × 2, to show the short prostrate spines.

B. *Cancrinella phosphatica* (Girty).. 29

Figs. 4, 5. Brachial and pedicle exterior views of an imperfect specimen, × 1, hypotype, U.S.N.M. No. 115573b, *Leiorhynchoidea-Cancrinella* zone, loc. 806i.

Figs. 6-8. Side, pedicle, and posterior views of an imperfect specimen showing well the wrinkles on the hinge, × 1, hypotype, U.S.N.M. No. 115572a, horizon and locality same as figures 4, 5.

Figs. 9, 10. Anterior view of a specimen (same as figs. 4 and 5) showing the short prostrate spines; 9, × 2, 10, × 1. Hypotype, U.S.N.M. No. 115573b, horizon and locality, same as figures 4, 5.

Fig. 11. Pedicle view of an imperfect specimen showing the costellae and spine bases, × 1, hypotype, I.G.M., horizon and locality same as figures 4, 5.

C. *Anidanthus alatus* Cooper, new species.............................. 30

Figs. 12-15. Anterior, brachial, side, and posterior views of a fairly large individual, holotype, U.S.N.M. No. 115471, × 1, *Anidanthus* zone, loc. 806n.

Figs. 16-18. Posterior, pedicle, and side views of the same specimen, × 2.

Fig. 19. Hinge area of same specimen showing hinge spine bases, × 3.

Fig. 20. Enlargement of venter of same specimen showing tubular spine bases, × 4.

Fig. 21. Brachial view of a smaller specimen, × 1, paratype, U.S.N.M. No. 115590a. Horizon and locality same as figures 12-15.

Fig. 22. Same specimen, × 2, showing lamellose anterior margin of brachial valve.

Fig. 23. Same specimen, × 3, showing the hinge spine bases and the peculiar ornamentation of the ear.

Fig. 24. Pedicle interior showing the large swollen adductor platform, × 1, paratype, U.S.N.M. No. 115572b. Horizon and locality same as figures 12-15.

Figs. 25, 26. Fragment of a brachial valve showing (25) median ridge, cardinal process, and adductor scars, × 2, and (26) the myophore of the cardinal process, × 2, paratype, U.S.N.M. No. 115572a, loc. 806n.

Plate 8

Dictyoclostus depressus Cooper, new species.............................. 32

Figs. 1-4. Anterior, pedicle, posterior and side views of a large individual holotype, U.S.N.M. No. 115467, × 1, *Dictyoclostus* zone, loc. 806k.

Figs. 5, 6. Brachial interiors, × 1 and × 2, respectively, showing cardinal process, median ridge, brachial impression, and high marginal ridge. Paratype, U.S.N.M. No. 115483a, *Anidanthus* zone, loc. 806n.

Figs. 7, 8. Fragment of posterior part of brachial interior (7) showing cardinal process and adductor scars, and (8) exterior of same specimen showing myophore of cardinal process, both × 2. Paratype, U.S.N.M. No. 115483b, horizon and locality same as figures 5, 6.

Fig. 9. Brachial view of a specimen partially covered by chert, × 1. Paratype, U.S.N.M. No. 115561, *Dictyoclostus* zone, loc. 806k.

Fig. 10. Section through median line of a large specimen showing long trail, thickened pedicle visceral region, thickened shell along periphery of brachial visceral region, and ponderous cardinal process, × 1. Paratype, U.S.N.M. No. 115468, *Dictyoclostus* zone, loc. 806k.

PLATE 9

A. *Muirwoodia* species 41

Figs. 1-4. Posterior, pedicle, anterior and side views of a large specimen, U.S.N.M. No. 115568, × 1, *Cancrinella* zone, loc. 806i.

Figs. 5-7. Anterior, pedicle, and side views of a smaller specimen, I.G.M., with somewhat deeper sulcus, × 1, horizon and locality same as figures 1-4.

B. *Dictyoclostus depressus* Cooper, new species........................ 32

Figs. 8-11. Anterior, pedicle, side, and posterior views, respectively, of a medium-sized specimen, paratype, U.S.N.M. No. 115482, × 1, *Dictyoclostus* zone loc. 806k.

Fig. 12. Exterior of a brachial valve, × 1, showing recumbent spines attached on the inside of the curved margin. Paratype, U.S.N.M. No. 115490a, *Anidanthus* zone, loc. 806n.

Fig. 13. Same, enlarged × 2.

PLATE 10

A. *Dictyoclostus depressus* Cooper, new species........................ 32

Figs. 1-4. Side, pedicle, anterior, and posterior views of a specimen preserving the long trail, × 1, paratype, I.G.M., *Anidanthus* zone, loc. 806n.

B. *Dictyoclostus depressus* subspecies................................ 33

Figs. 5-8. Posterior, pedicle, anterior, and brachial views, respectively, of a specimen, U.S.N.M. No. 115484, lacking the trail, × 1. Portions restored in plaster. *Spiriferellina* zone, loc. 806g.

C. *Liosotella rugosa* Cooper, new species.............................. 37

Fig. 9. Specimen showing the row of spines overhanging the ear, × 2, paratype, U.S.N.M. No. 115459a, *Anidanthus* zone, loc. 806n.

PLATE 11

A. *Liosotella subrugosa* Cooper, new species.......................... 39

Figs. 1-3. Pedicle, side, and anterior views of a large specimen showing the numerous costae and spine bases, × 1, paratype U.S.N.M. No. 115461, upper *Spiriferellina* zone, loc. 806d.

Fig. 4. Brachial view of a somewhat narrower specimen, × 1, paratype, I.G.M. Horizon and locality same as figures 1-3.

B. *Liosotella angustata* Cooper, new species........................... 37

Figs. 5-7. Brachial, pedicle, and posterior views of a specimen lacking part of the front margin, × 1, holotype, U.S.N.M. No. 115465, *Anidanthus* zone, loc. 806n.

Figs. 8-10. Pedicle, anterior, and side views of a nearly perfectly formed pedicle valve, × 1, paratype, U.S.N.M. No. 115466. Horizon and locality same as figures 5-7.

C. *Liosotella rugosa* Cooper, new species.............................. 37

Figs. 11, 12. Posterior and pedicle views of an imperfect specimen showing the nearly smooth umbo and ear and the costate and spinose venter and trail, × 1, paratype I.G.M., *Anidanthus* zone, loc. 806n.

Fig. 13. Brachial view showing narrow median fold, × 1, paratype, U.S.N.M. No. 115459a. Horizon and locality same as figures 11, 12.

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B. *Spiriferella,* species 1.. 64

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B. *Hustedia elongata* Cooper, new species................................ 67

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B. *Punctospirifer convexa* Cooper, new species 67

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D. *Spiriferellina sonorensis* Cooper, new species.......................... 69

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B. *Glossothyropsis magna* Cooper, new species............................ 73

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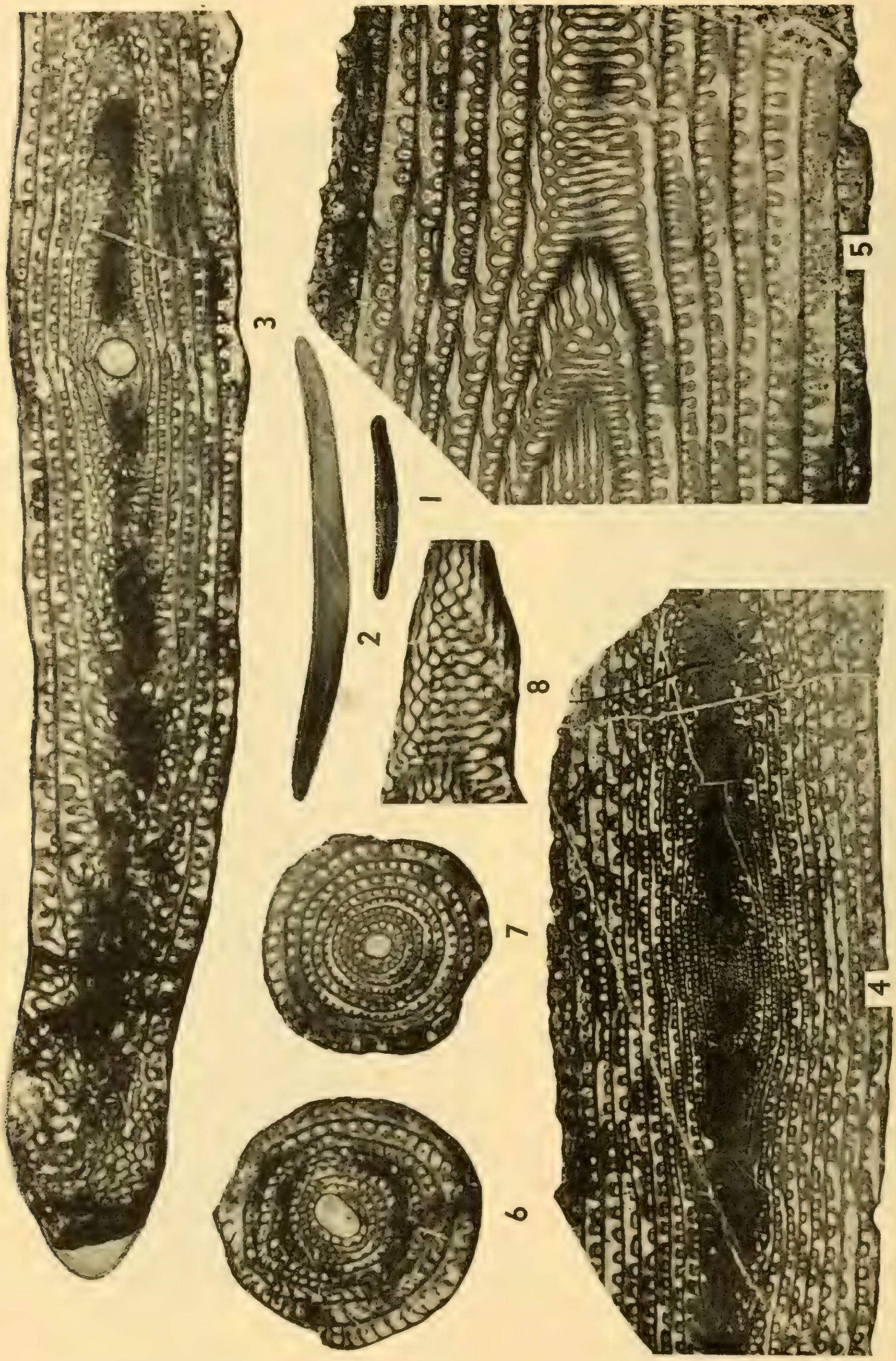
PLATES

1

2

VIEWS OF PERMIAN STRATA IN THE MONOS HILLS, NORTHEAST OF EL ANTIMONIO

(SEE EXPLANATION OF PLATES AT END OF TEXT.)



PARAFUSULINA

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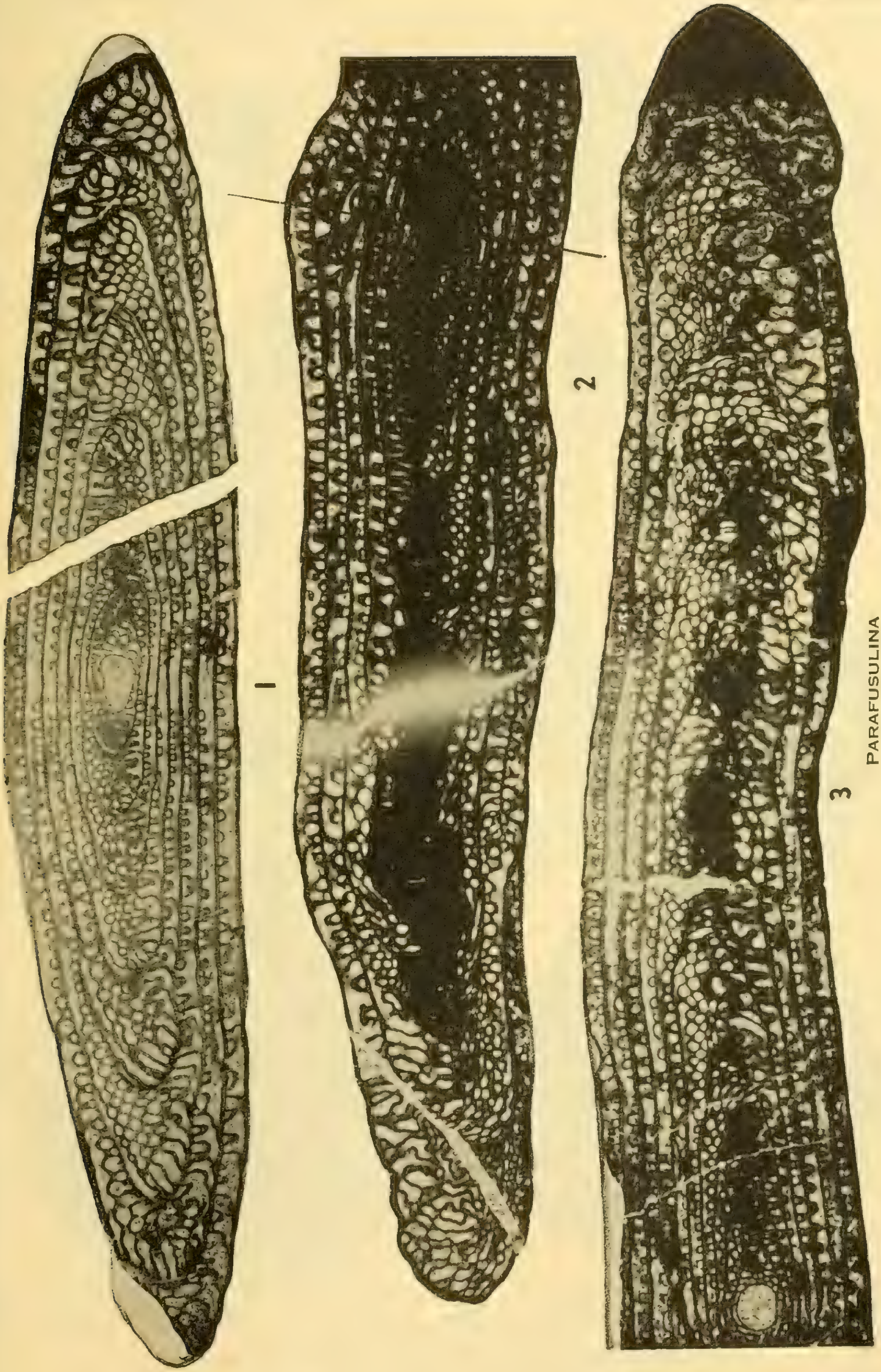

PARAFUSULINA

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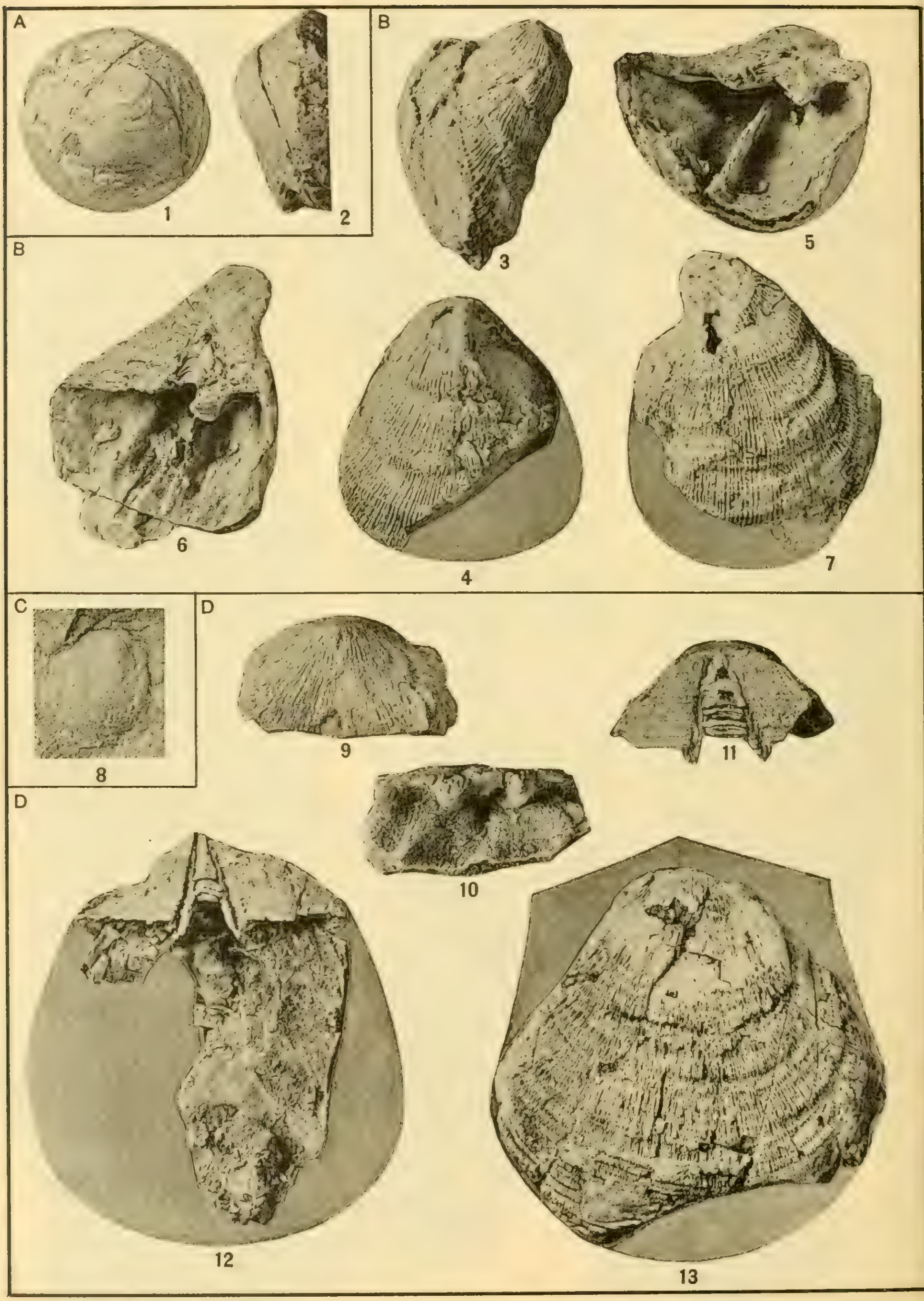

ORBICULOIDEA, DERBYIA, AND STREPTORHYNCHUS

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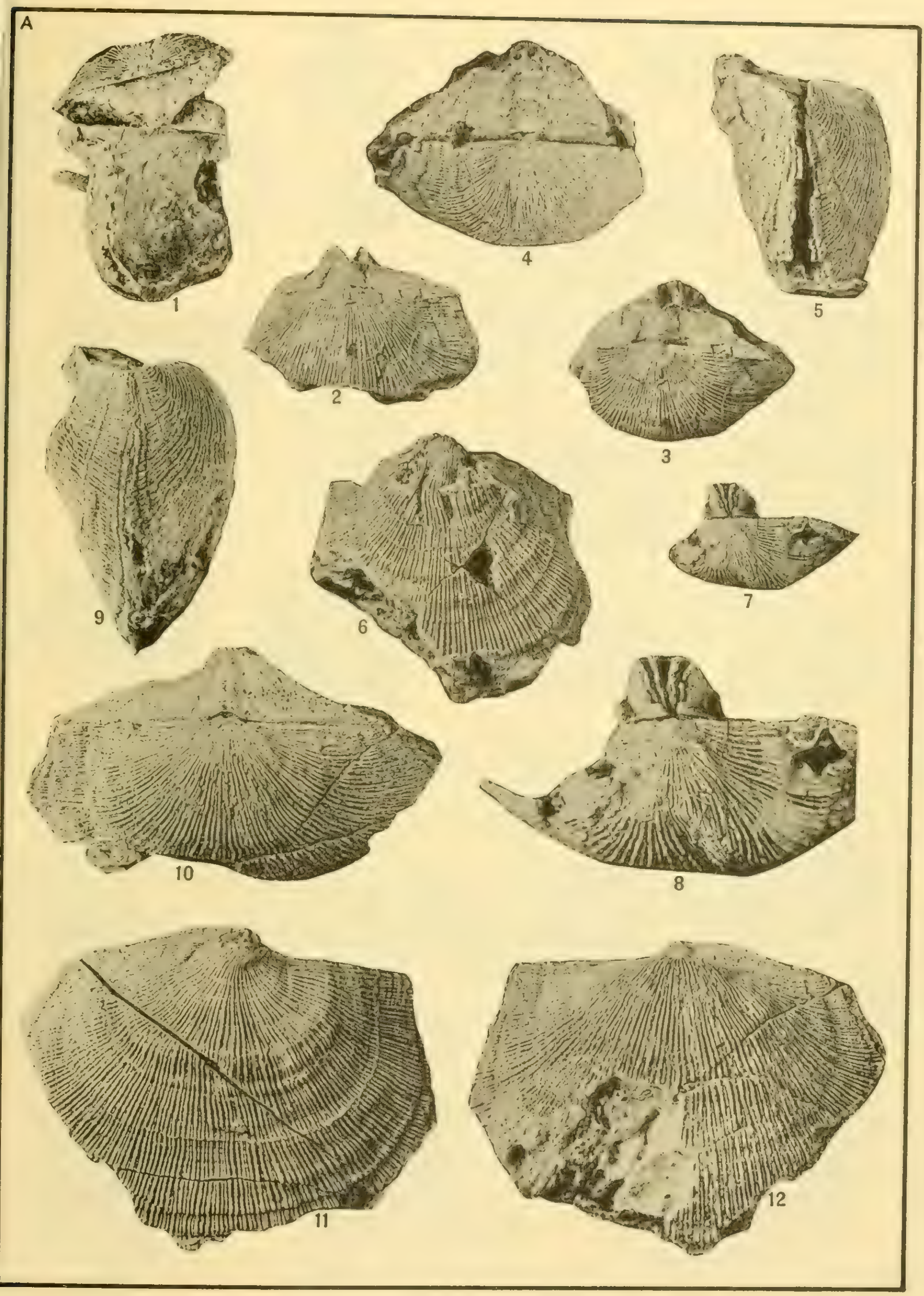

DERBYIA

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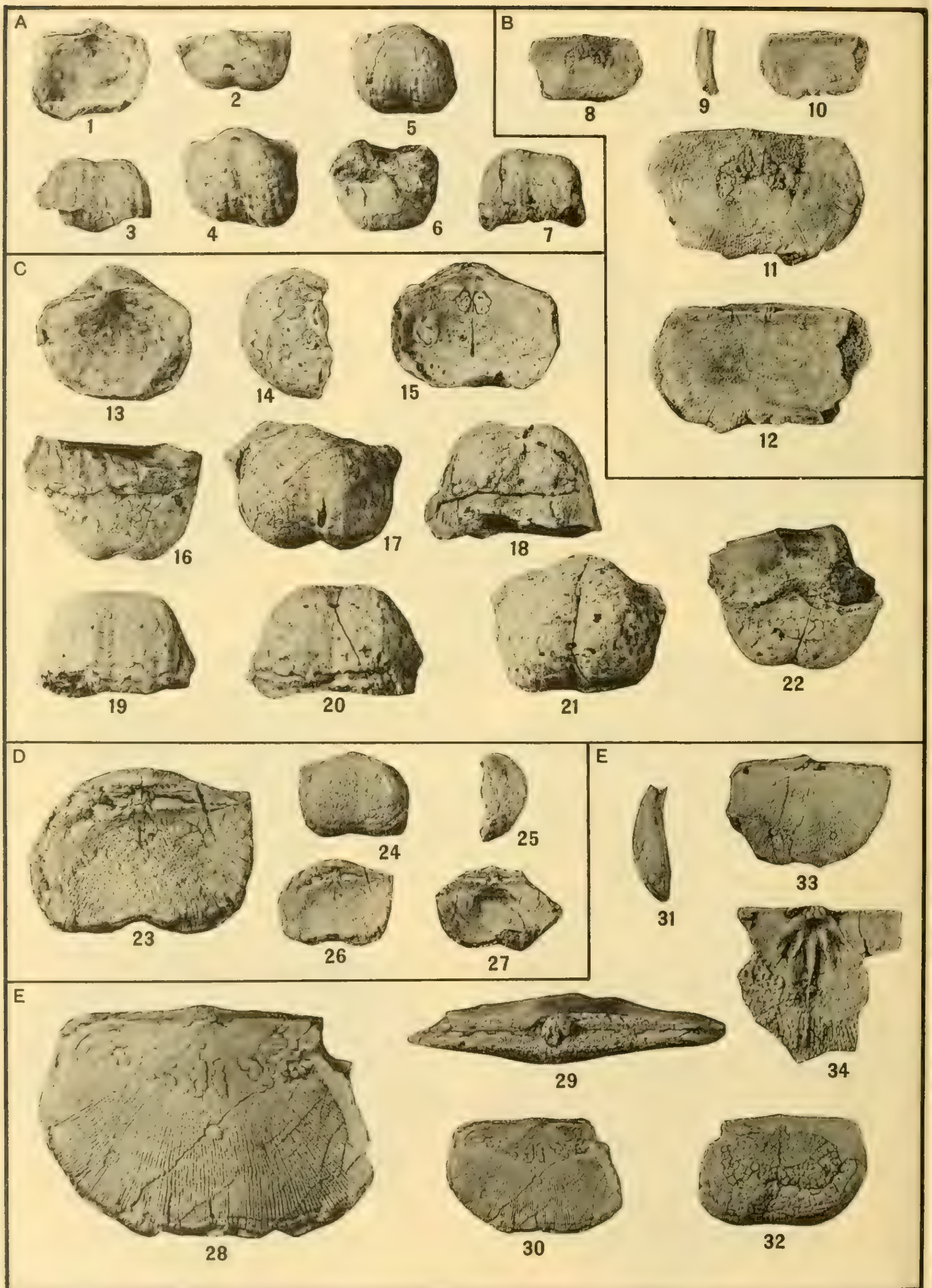

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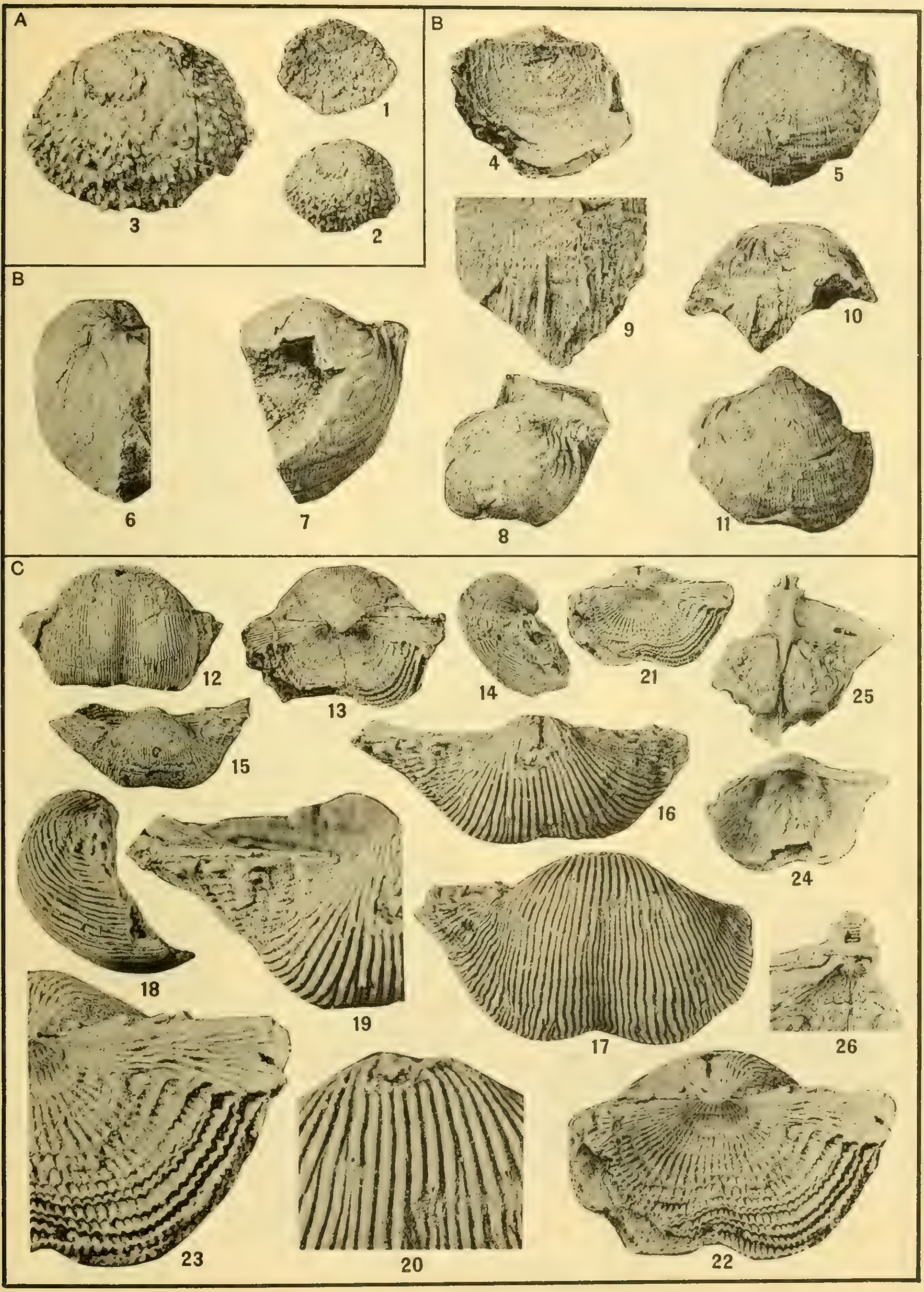

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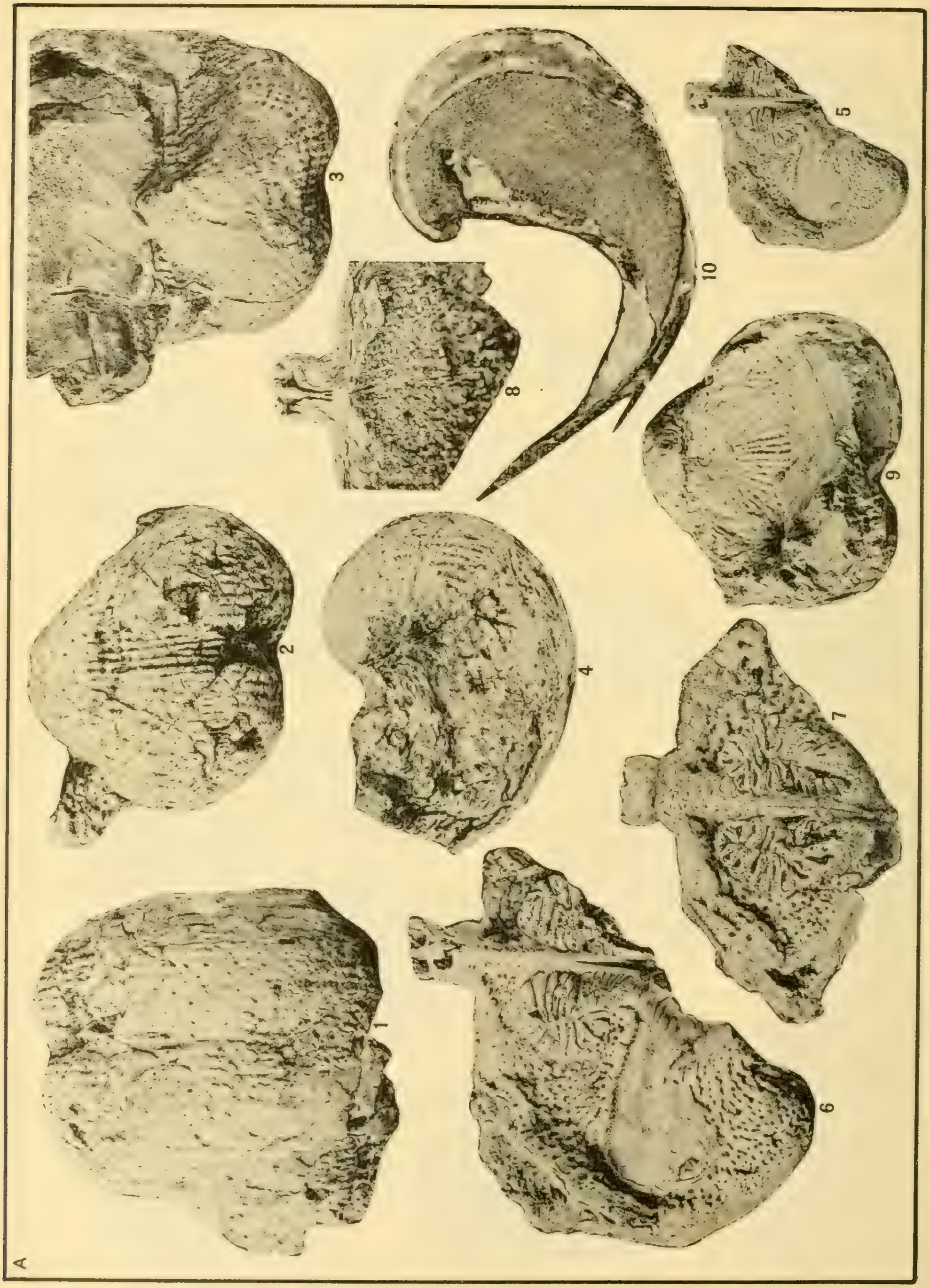

DICTYOCLOSTUS

MUIRWOODIA AND DICTYOCLOSTUS

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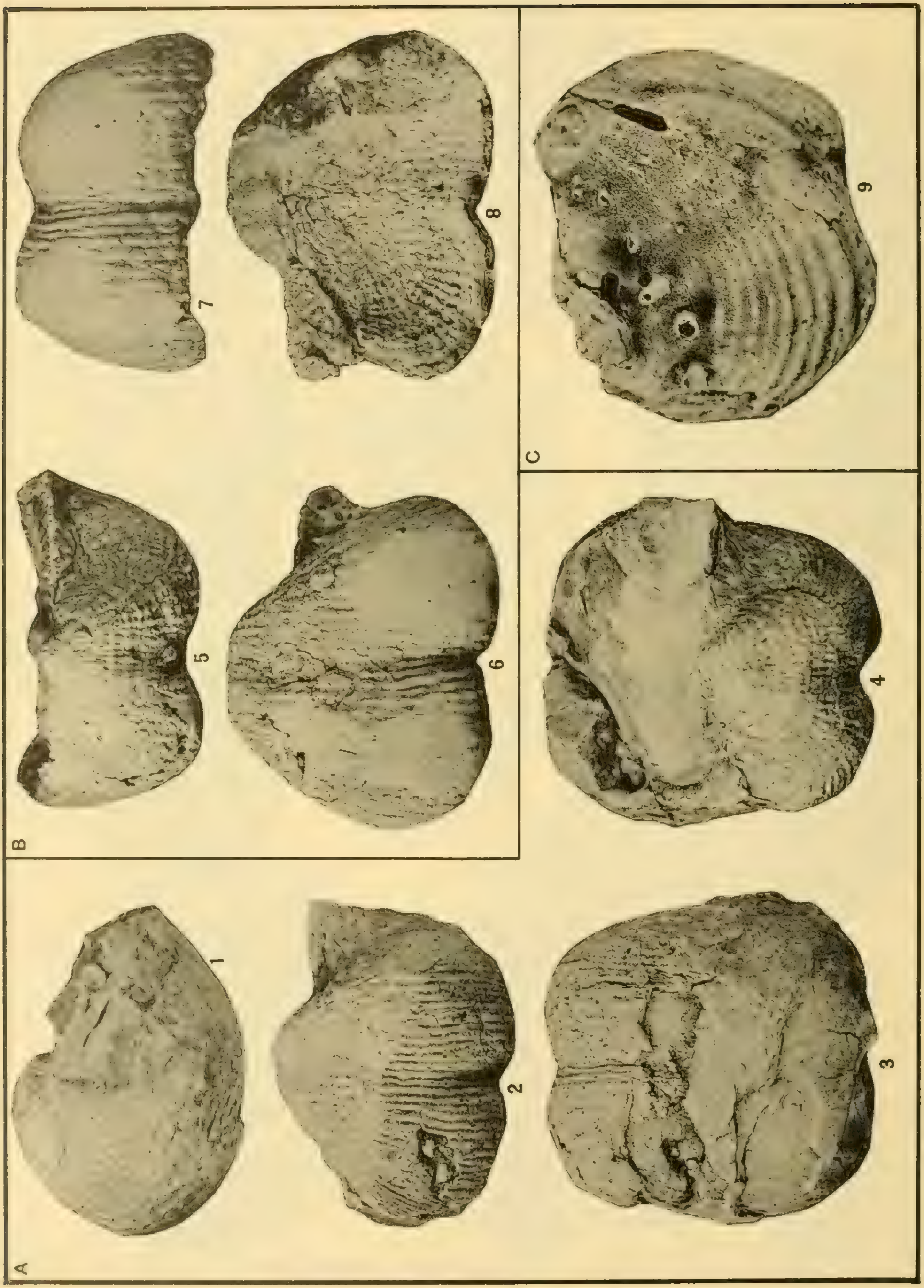
A
1
2
3
B
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C
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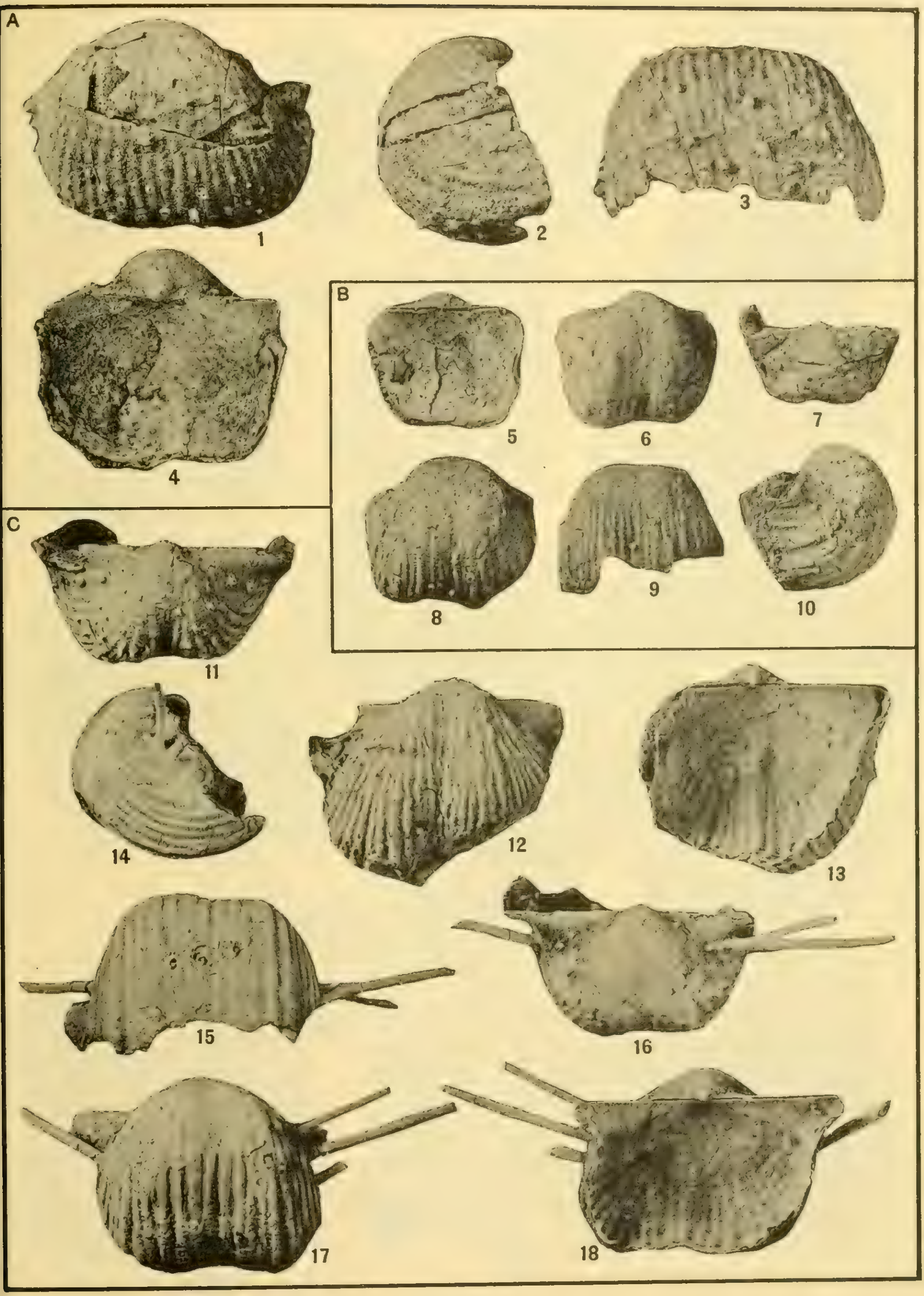

LIOSOTELLA

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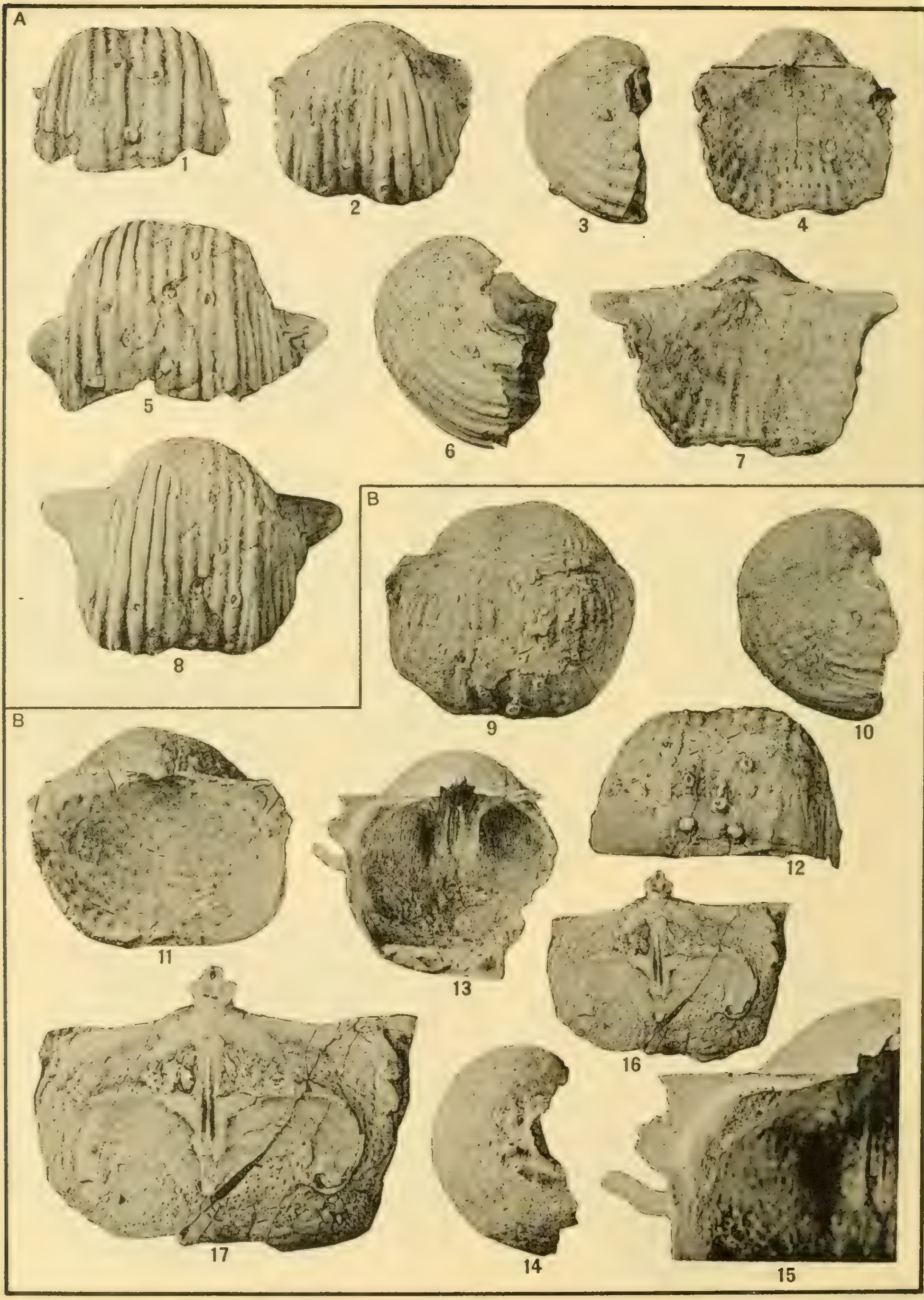

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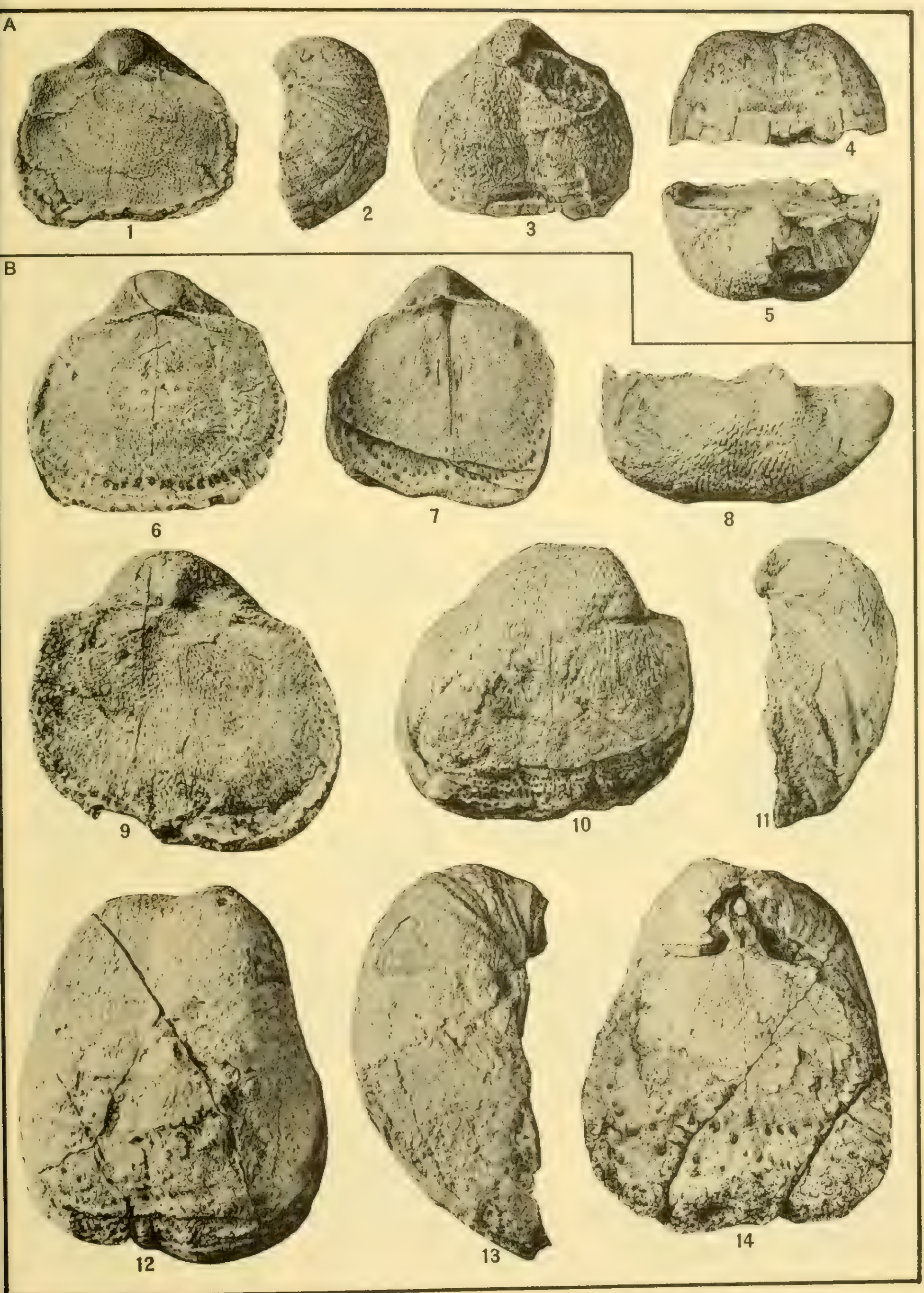

WAAGENOCONCHA

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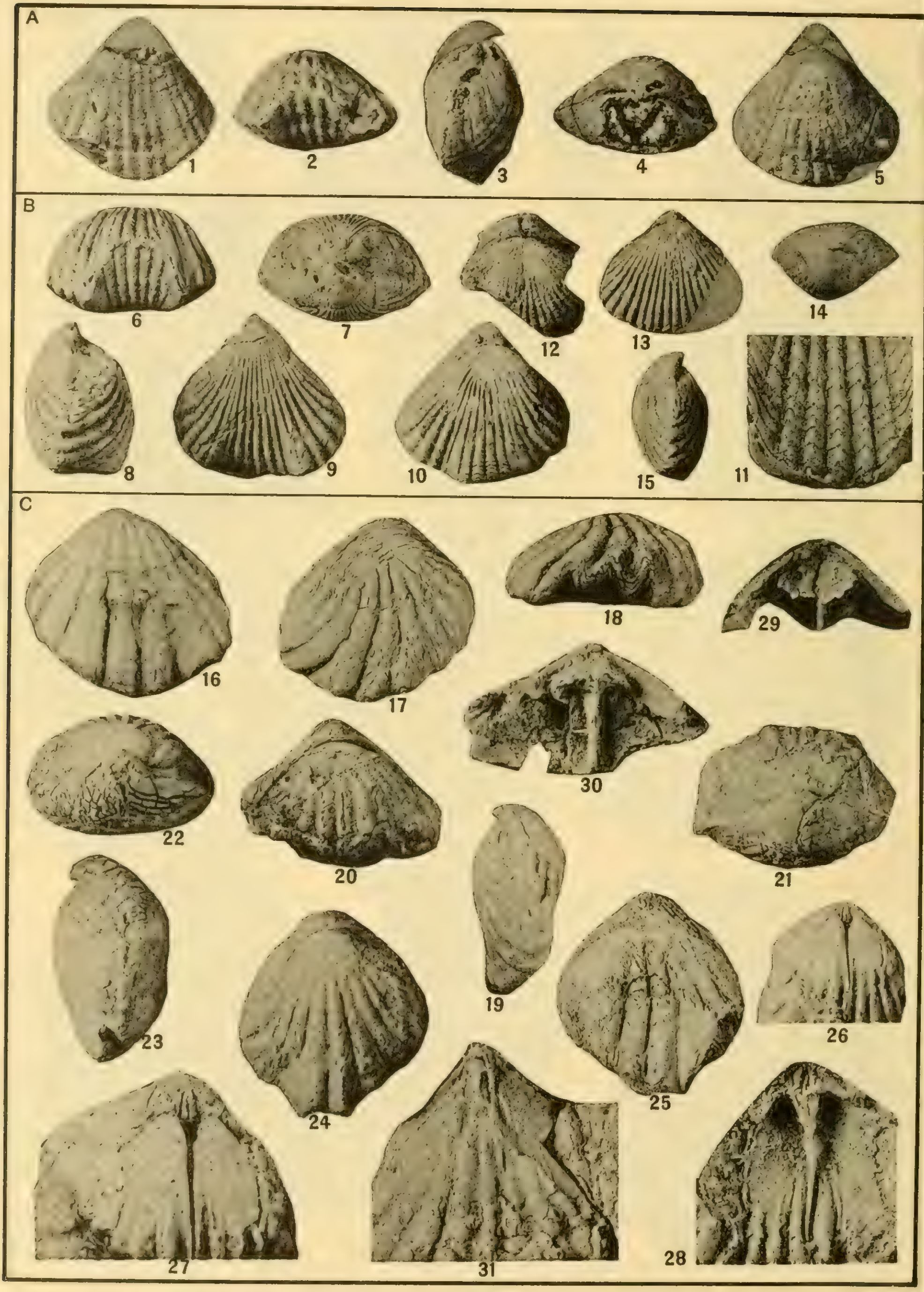

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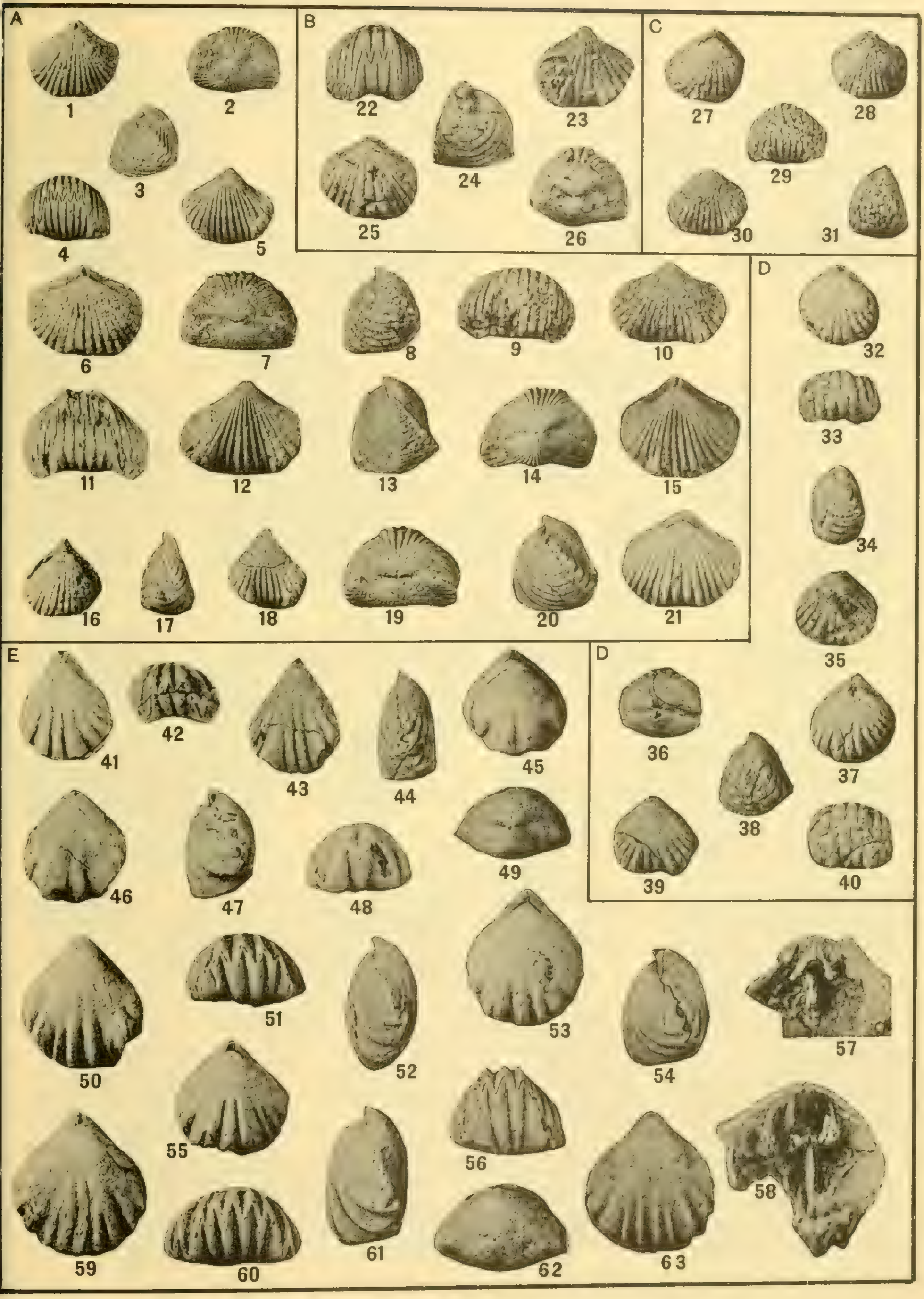

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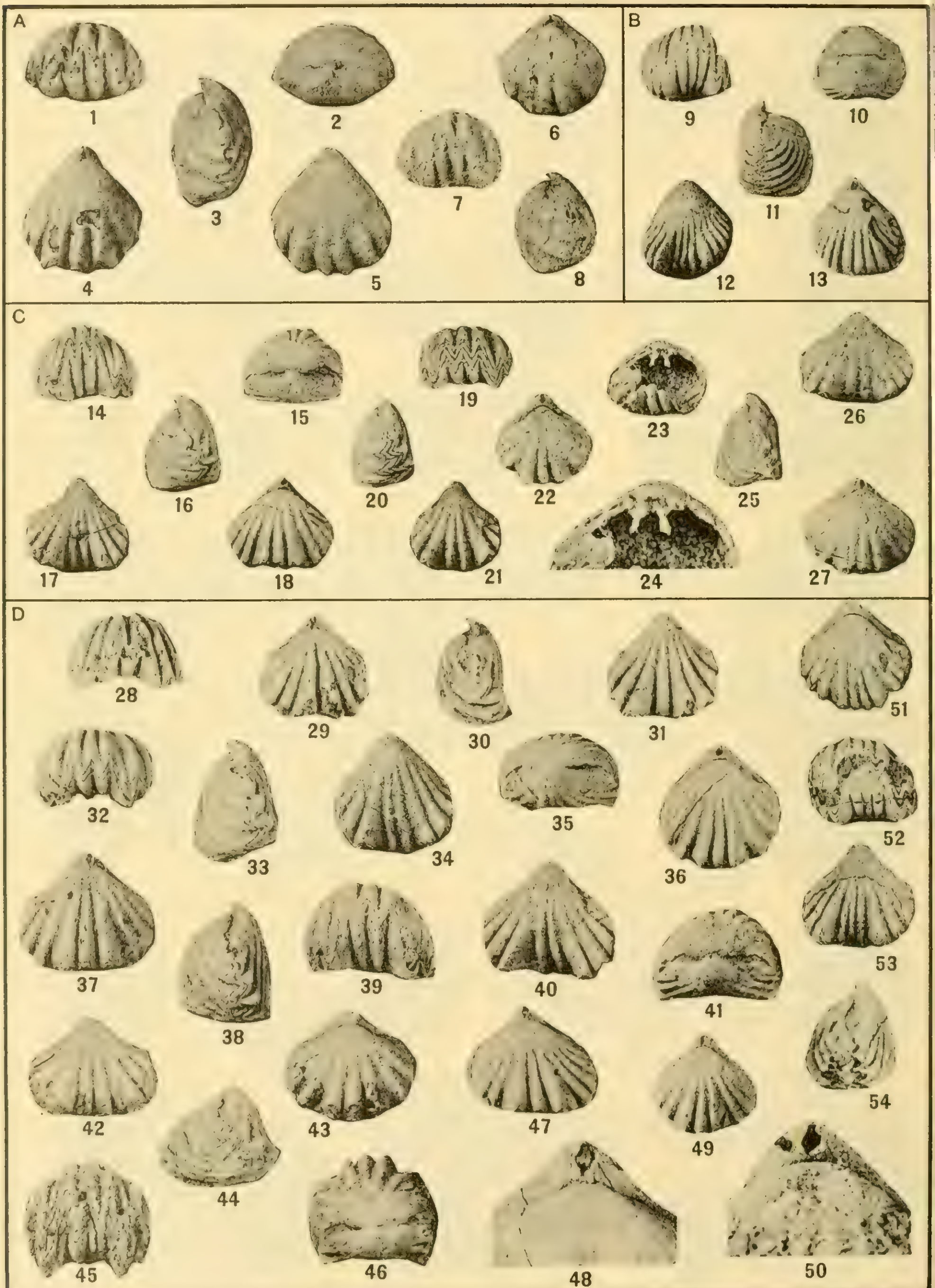

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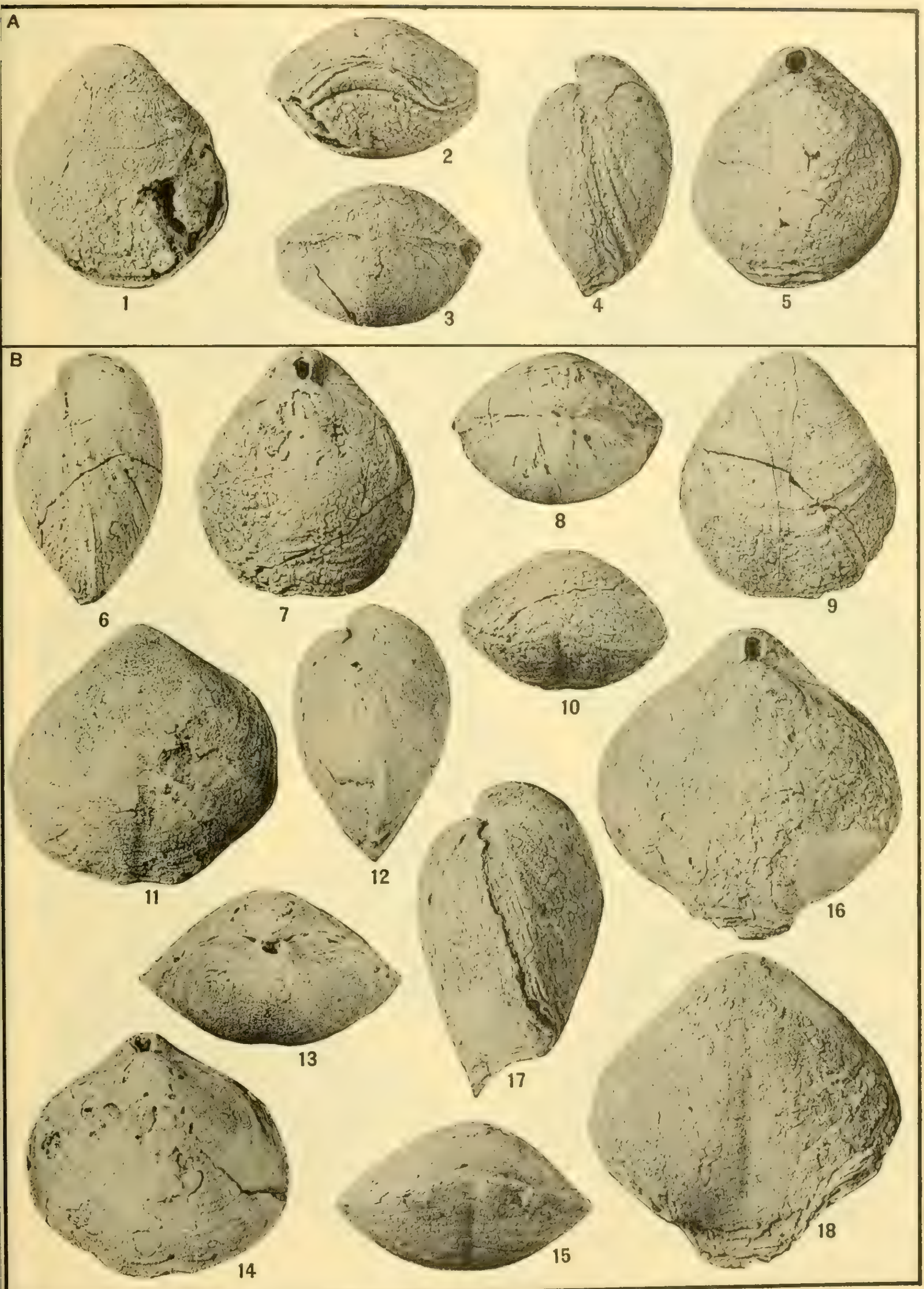

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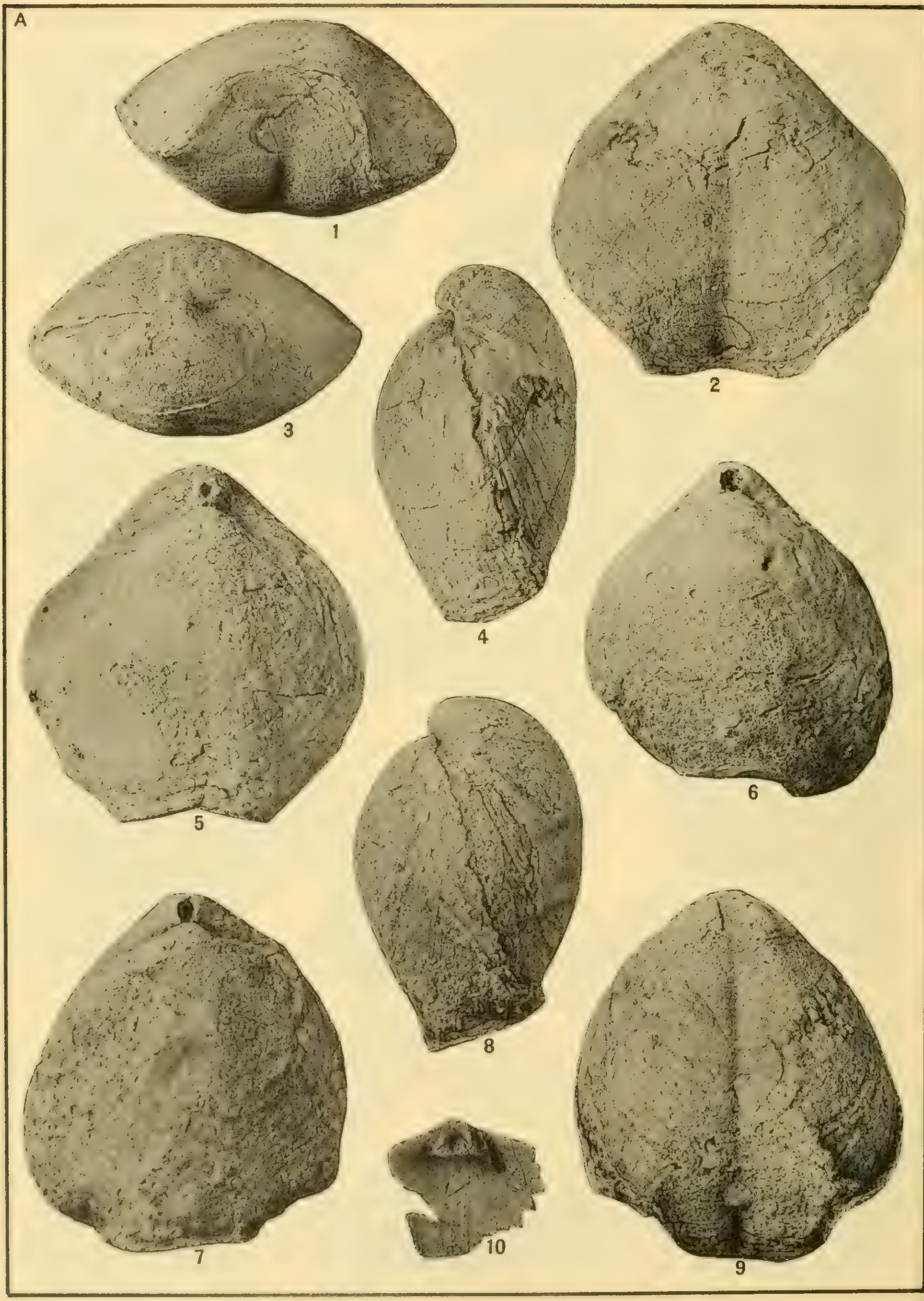

COMPOSITA

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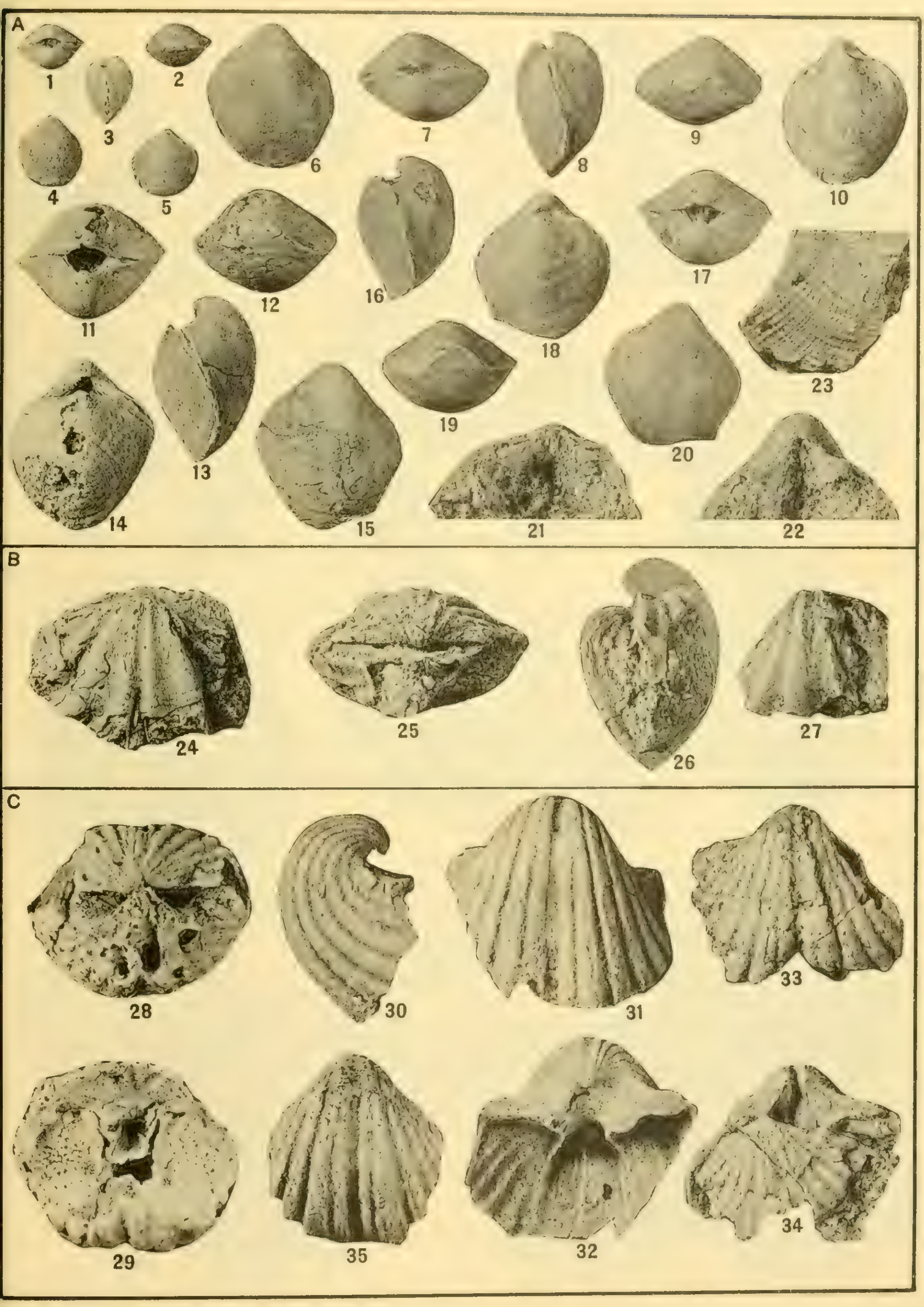

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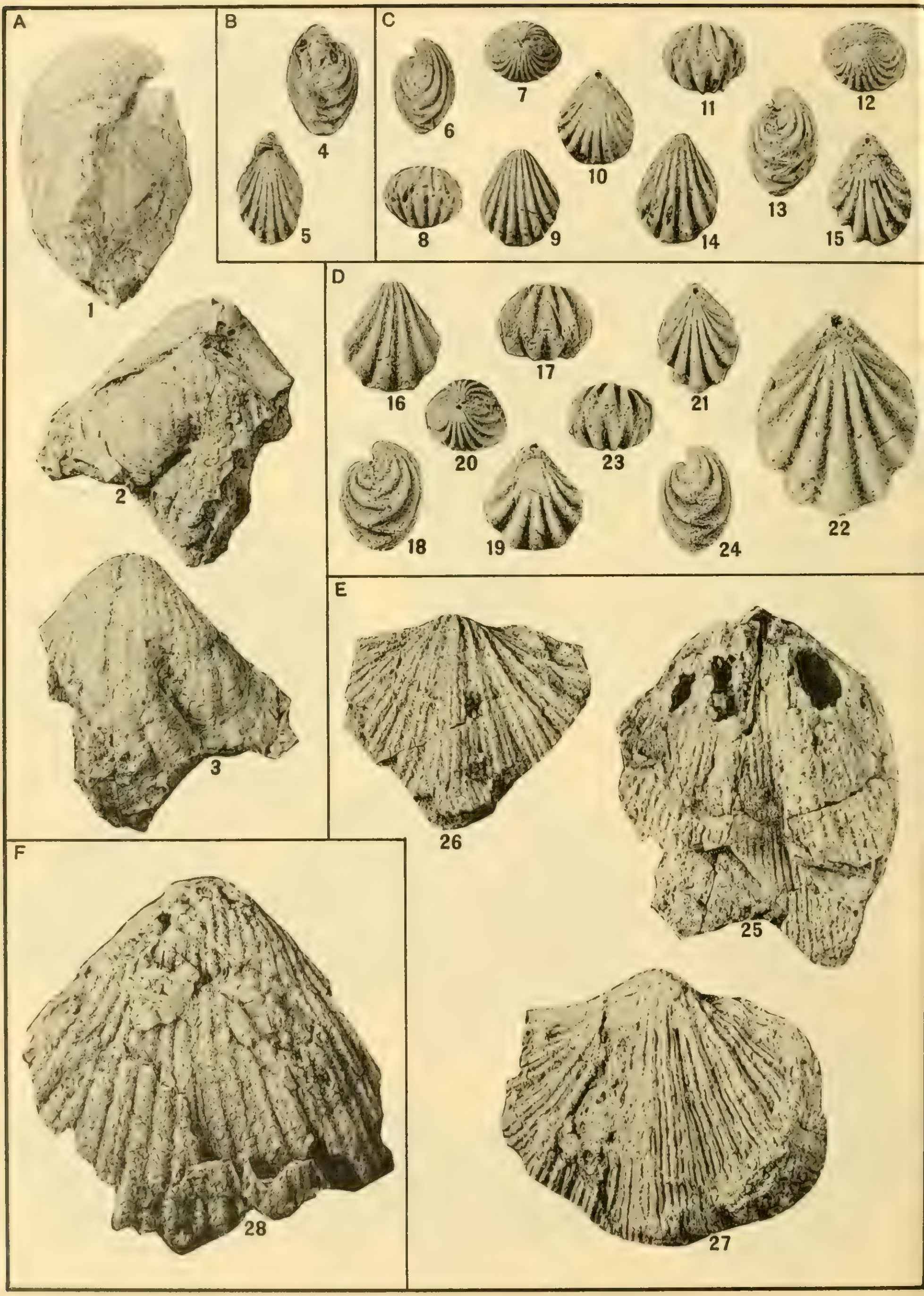

SPIRIFERELLA, HUSTEDIA, AND NEOSPIRIFER

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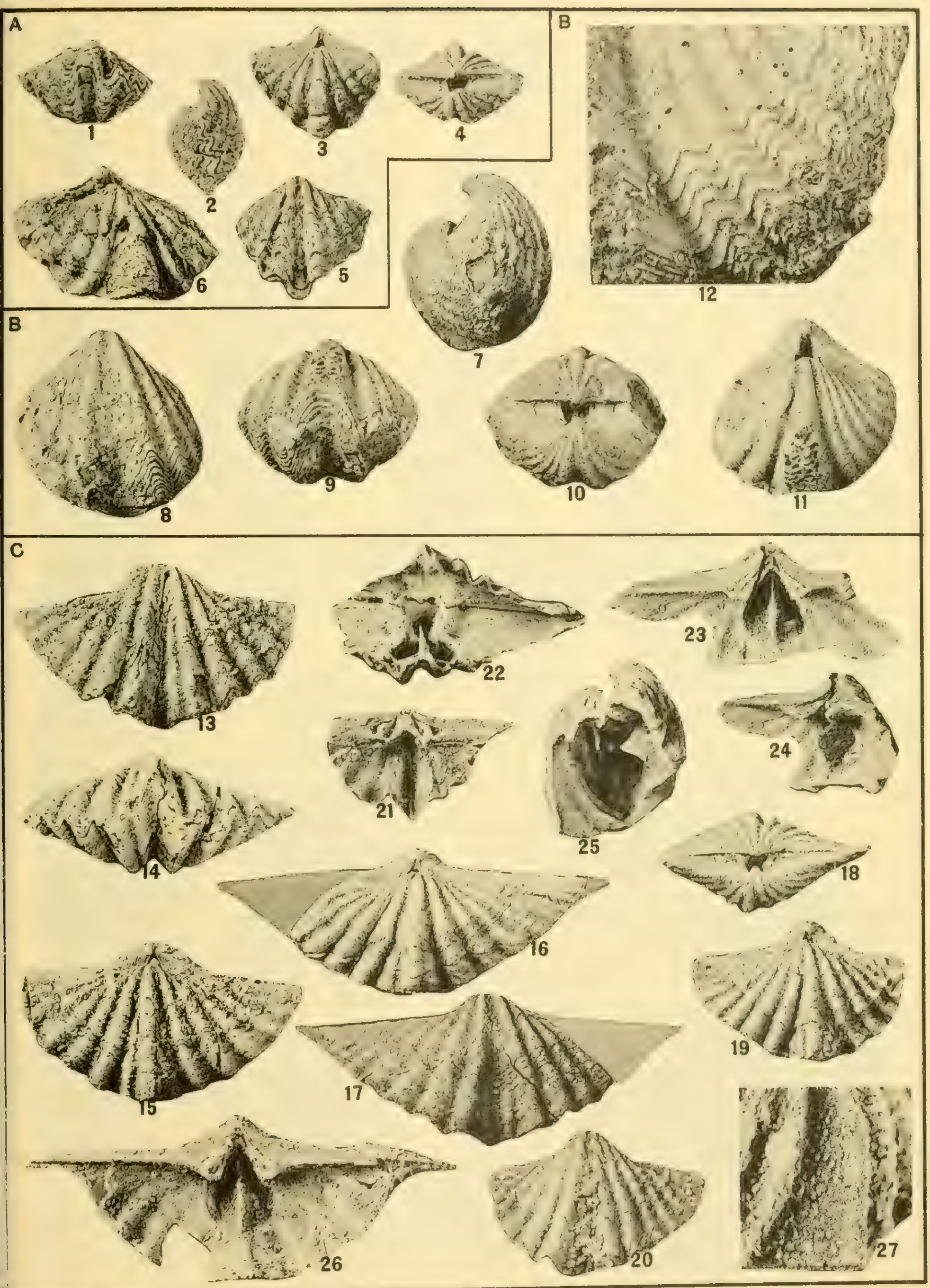

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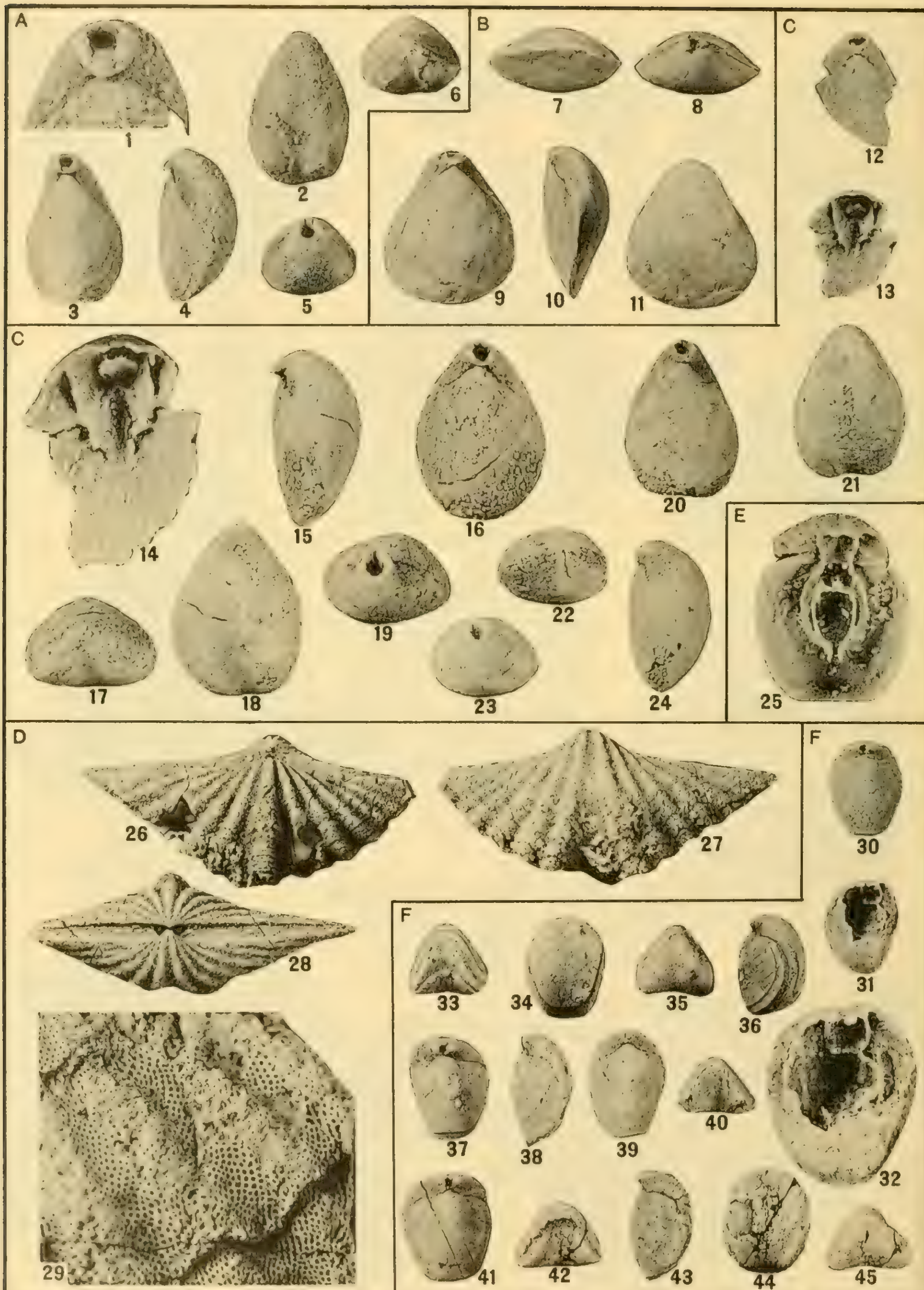

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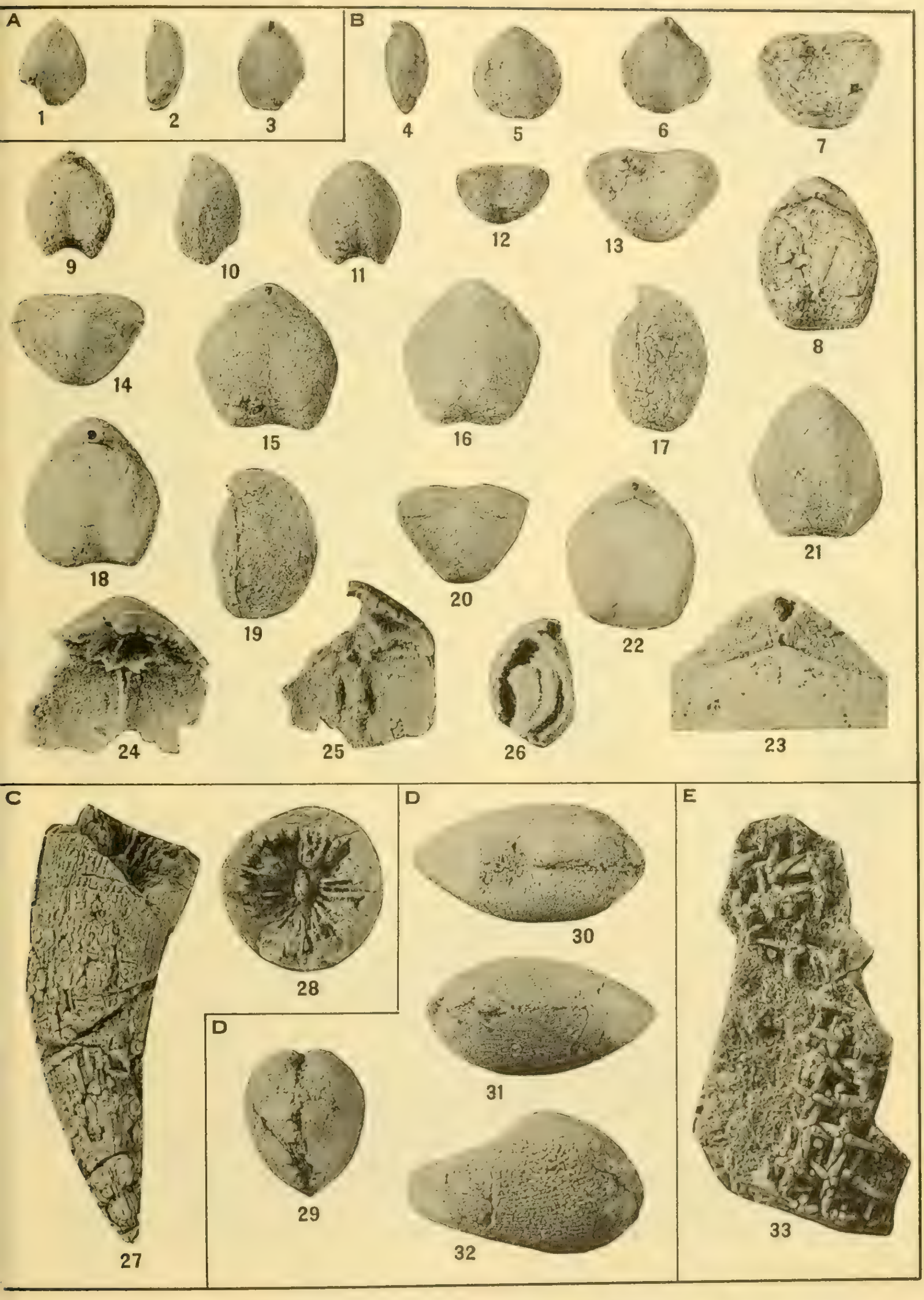

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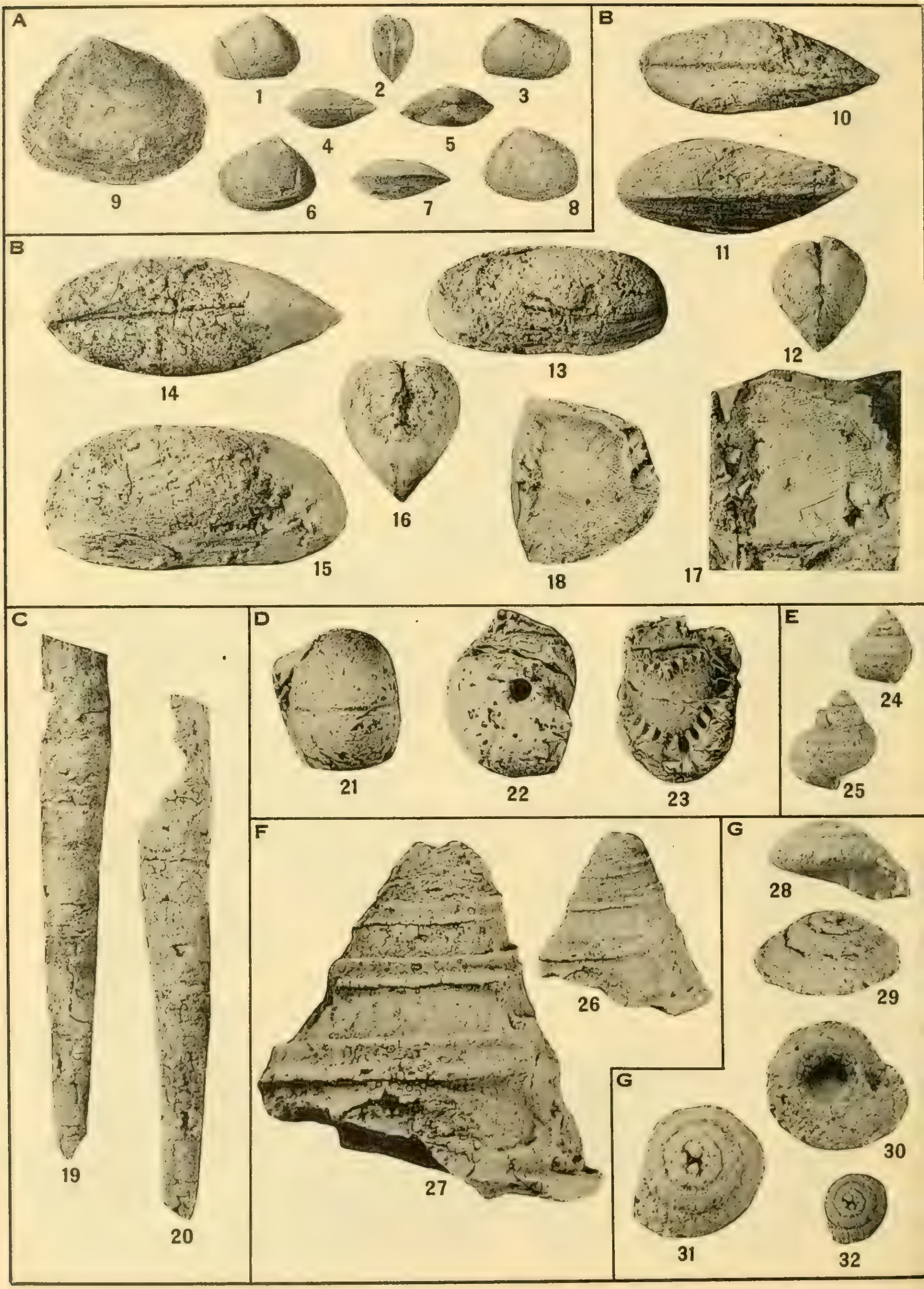

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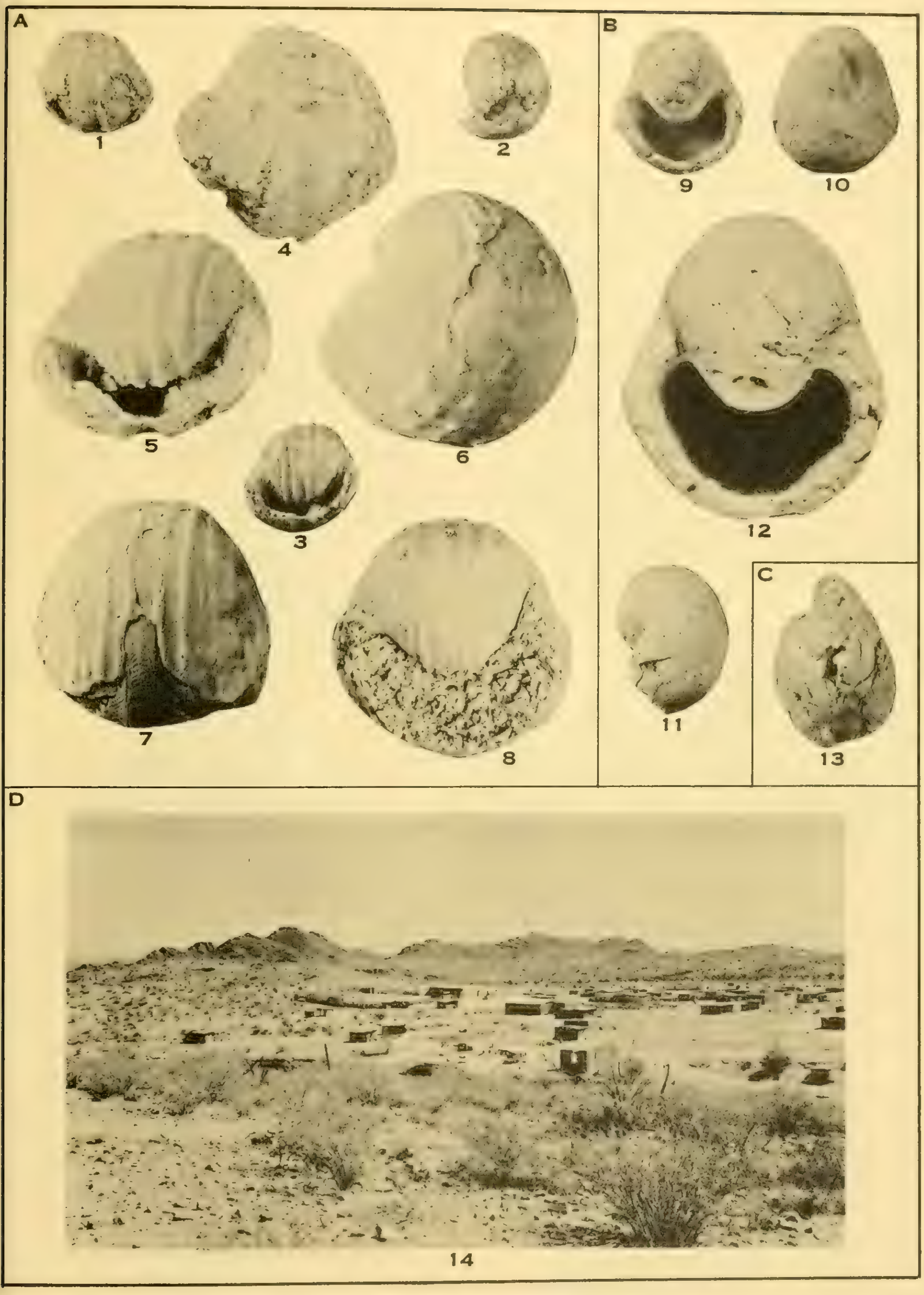

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SMITHSONIAN MISCELLANEOUS COLLECTIONS
VOLUME 119, NUMBER 3
(END OF VOLUME)

Charles D. and Mary Vaux Walcott
Research Fund

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(WITH NINE PLATES)

BY
W. H. EASTON
JOHN E. SANDERS
J. BROOKES KNIGHT
ARTHUR K. MILLER

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FOREWORD

This is the third of a series of descriptive papers on the paleontology of the rocks exposed in the vicinity of Caborca, Sonora. The faunas of the Cambrian and Permian sediments have already been published.[1] This description of the Mississippian fossils is the last extensive paper in the series. Pre-Cambrian algae and a few Devonian species are the only other fossils collected by the expeditions of 1943 and 1944.

The work in Sonora was undertaken to establish a Paleozoic sequence in that region. Some excitement resulted from the early report of Cambrian in an area that had hitherto been thought to contain mostly Mesozoic rocks. The work of A. R. V. Arellano of the Instituto Geológico de México and G. A. Cooper of the Smithsonian Institution resulted in the discovery of Lower Cambrian and Devonian as well as confirmation of the presence of Middle Cambrian, Mississippian, and Permian.

The Mississippian rocks occur in a limited area, actually consisting of two small hills about half a mile apart. The easternmost of the hills produced a fair fauna but only a few fossils were found in the western hill. These were sufficient for dating, however. Stratigraphically the Sonora Mississippian offers nothing unusal and can be correlated satisfactorily with Mississippian strata of the Great Basin Province of the United States.

In connection with correlation of the fauna of the eastern hill it is of interest to note here that the Mexican fossils were examined by Arthur L. Bowsher, United States Geological Survey. Mr. Bowsher has studied intensively the fossils and stratigraphy of the Mississippian of southern New Mexico where a fine fossiliferous sequence has been described by him and Dr. Lowell R. Laudon of the University of Wisconsin.[2] It is Mr. Bowsher's opinion that the fauna of the eastern

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[1] Cambrian stratigraphy and paleontology near Caborca, northwestern Sonora, Mexico. Smithsonian Misc. Coll., vol. 119, No. 1, 1952: Introduction and stratigraphy, by G. A. Cooper and A. R. V. Arellano, pp. 1-23, pls. 1-5, figs. 1-7; *Girvanella,* by J. H. Johnson, pp. 24-26, pl. 6; Pleospongia, by V. J. Okulitch, pp. 27-35, pls. 7-10; Brachiopoda, by G. A. Cooper, pp. 36-48, pls. 11-13; The original collection of Cambrian trilobites from Sonora, by A. Stoyanow, pp. 49-59, pl. 14; Trilobites, by C. Lochman, pp. 60-101, pls. 15-31, figs. 8, 9.

Permian fauna at El Antimonio, western Sonora, Mexico. Smithsonian Misc. Coll., vol. 119, No. 2, 1953: Stratigraphy and faunal zones, by G. A. Cooper, pp. 1-13, pl. 1, figs. 1-3; A giant Permian fusuline from Sonora, by C. O. Dunbar, pp. 14-19, pls. 2, 3; Corals, by H. Duncan, p. 20, pl. 23; Sponges, Brachiopoda, Pelecypoda, and Scaphopoda, by G. A. Cooper, pp. 21-80, pls. 4-24A,B,C, 25D; Cephalopoda, by A. K. Miller, pp. 81-82, pl. 24D; Gastropoda, by J. B. Knight, pp. 83-90, pls. 24E, 25A,B,C.

[2] Laudon, L. R., and Bowsher, A. L., Mississippian formations of southwestern New Mexico. Bull. Geol. Soc. Amer., vol. 60, pp. 1-88, 1949.

hill near Bisani, the fossils of which are described herein, are most like those of the Andrecito formation. In New Mexico this formation occupies a position intermediate between the Kinderhookian Caballero formation and the Osagian Lake Valley formation. Easton and Sanders in their comments below emphasize the intermediate character of the Mexican fauna.

Preparation by Cooper of the Mississippian fossils from Sonora offered considerable difficulty. These all proved to be silicified but the specimens on being freed from the limestone by acid were unusually fragile. Many were lost in the process because they were seamed with small cracks and fell apart in the acid. Some were sufficiently large that they could be pieced together and thus saved. The preparation of the specimens thus proved a laborious and time-consuming task. In spite of the difficulties a fair number of species was obtained.

The middle portion of the eastern hill from which most of the fossils were taken contains much silica. In some of the silicious masses fossils were buried that could not be recovered. It is, therefore, interesting to note that a specimen of the large brachiopod *Syringothyris* was seen on the outcrop but could not be freed.

I take this opportunity to thank my colleagues for describing the interesting fossils recorded here. Dr. W. H. Easton kindly studied the corals and became so interested in them and their relationships to the Mississippian corals of western United States that he visited the Caborca region with a party of students from the University of Southern California. This separate expedition yielded additional material. Thanks are extended to Dr. John E. Sanders of Yale University for his work on the Mississippian brachiopods of the Caborca area. Dr. Sanders has been studying the little-known sequences of Mississippian in eastern Tennessee and was thus able to bring his knowledge of this region to his study of these western Mexican fossils. Although Dr. J. Brookes Knight was unable to make good specific identifications of many of the snails, he was able to indicate the generic representation of the Gastropoda in a geographic area in which they are poorly known. Thanks go to him for his work on this poorly preserved part of the fauna. Indebtedness must be acknowledged to Dr. A. K. Miller, University of Iowa, for describing the one specimen of cephalopod collected. This is a poor specimen at best, but it is an interesting and important genus of the Mississippian.

G. Arthur Cooper
Head Curator, Department of Geology
United States National Museum

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Charles D. and Mary Vaux Walcott Research Fund

MISSISSIPPIAN FAUNA IN NORTHWESTERN SONORA, MEXICO

MISSISSIPPIAN CORALS FROM NORTHWESTERN SONORA, MEXICO

By W. H. Easton
University of Southern California

(Plates 1, 2, 9C; text figures 1-3)

INTRODUCTION

The first material upon which this study is based was collected in 1943 and 1944 by G. A. Cooper and A. R. V. Arellano during the course of geologic investigations carried on by them in the vicinity of Caborca in northwest Sonora, Mexico. During the years between first preparation of the report (1948) and now (March 1956) the writer has had many opportunities to study and collect from strata of similar age and physical character at numerous localities in California, Nevada, Arizona, and Utah. Accordingly, these recent investigations also permit a close correlation of the coralline strata from Sonora with deposits in the Great Basin of the western United States, as well as with strata in Missouri (this latter resource being necessary in the earlier draft of the paper). In view of the significant similarity of these Mexican corals with those from the western United States, the writer eventually was encouraged to visit the Mexican locality himself in order to study the stratigraphy first hand and to acquire duplicate collections for the University of Southern California. This collecting trip was made in December 1955.

ACKNOWLEDGMENTS

The writer takes pleasure in acknowledging his indebtedness to Dr. G. A. Cooper of the United States National Museum for making available the specimens collected by Cooper and Arellano. He is indebted also to the following students from the University of Southern

California for assistance in the field and for the use of equipment on this collecting trip: R. Hammer, D. Ingebrigtsen, J. LoBue, R. Pesci, and R. Sherman. Financial assistance in this project was made available by the University of Southern California. The physical features and paleogeographic significance of the section will be presented in a publication of the International Geological Congress (XX) which was held at Mexico City in September 1956.

GEOLOGY

The alluvial plain near Bisani laps up against various isolated hills, the positions of which are shown in text figure 1. The hill from which most of the silicified fossils were collected is located 1.4 miles (2.2 kilometers) road distance [3] on a bearing N. 71° W. from the northeast fence corner of Bisani. Bisani is 13.3 miles (21.3 kilometers) west of the southwest corner of the town of Caborca. This hill is about 300 feet in diameter, is almost circular, and rises 65 feet above the playa lake on its west side. In addition to the above silicified fossils four more corals and a few brachiopods were collected from the north end of the small hill 0.5 mile west of the above-mentioned hill, or 2 miles west of Bisani.

The stratigraphic section on the main hill contains only 164 feet (53 meters) of strata, as shown in text figure 2. The fossiliferous portion of the outcrop consists mainly of a very cherty interval (unit 2 of the stratigraphic column) bounded by two lighter intervals.

A description of the measured section of Mississippian strata 1½ miles west-northwest of Bisani, Mexico, is given below. The top bed shown is on the eastern face of the hill, this being the apparent order of succession.

The writer entertains the greatest doubts that the apparent order of superposition as seen in the outcrops is the actual order of stratigraphic succession. For various reasons the solution of this elementary problem is confounded. The action of occasional strong currents and the presence, presumably, of shallow water, are testified to by broken and waterworn corals, disassociated brachiopod valves, and occasional streaks of coarse fossil debris such as criquina, in otherwise fine-grained sediments. Nevertheless, clear-cut instances of truncated crossbedding or graded bedding such as would indicate order of super-

[3] Incidentally, rural roads in this region, as is generally true in the arid parts of western North America, exist more from faith and less from ballast than do roads in moister climes, hence, great variation may exist from time to time in the interpretation of parts of the road system shown herein (see plate 9, C).

position were not seen by the writer, nor does he know of anyone who has visited the outcrop who was able on these grounds to verify the structural attitude. Bottom markings or other details at bedding planes seem to have been obliterated by the extensive shearing and gliding coincident with the deformation of these strata. As a matter of fact, all trace of bedding in several places has been destroyed by brecciation and by alteration through either recrystallization or dolomitization.

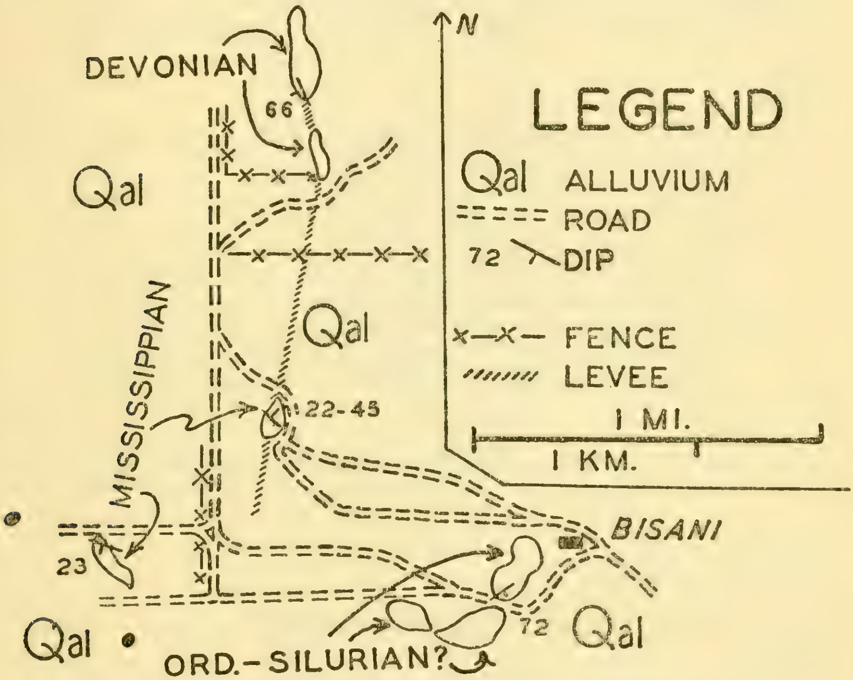

FIG. 1.—Sketch map of the geology near Bisani, Sonora, Mexico.

Older and younger strata crop out in the vicinity but not in continuity with these beds, so lithologic correlation is not possible. Moreover, the faunas of the beds are not distinct enough either to enable evaluation of evolutionary changes or to enable correlation with the inadequately known faunas of the western United States. As a result, discussions of the order of stratigraphic succession mostly concern the significance of orientation of corals present in various beds.

Almost all the simple zaphrenthid corals lie prostrate in parallelism with the bedding. Some, like *Caninophyllum,* also were abraded enough in locally strong currents to cause removal of most of the theca and thereby to expose the dissepiments. One remarkable speci-

men of *Caninophyllum* on the east side of the main hill, however, not only was oriented with its long axis normal to the planes of stratification but its calyx is encrusted with a spherical growth of *Syringopora* so as to make it abnormally topheavy. Although this aggregation may indicate that currents overturned a coral in a normal sedimentary sequence so that the *Syringopora* now points down, the concavity of laminations in the bedding over the upwardly directed apex of the *Caninophyllum* seem to indicate downward depression of soft sediment during growth. Moreover, it is difficult to imagine this elongate

	Feet
Top not exposed.	
1. Limestone, gray, medium-grained to fine-grained, 5 percent brownish weathering chert nodules	40
2. Limestone, as in bed 3, but chert amounts to about 75 percent of unit	19
3. Limestone, dark gray, mostly fine-grained, bedding up to 1 foot, 30-50 percent reddish-brown weathering, chert in nodules and beds, cliffy western face of hill, increasingly fossiliferous up-section	74
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5. Criquina, gray, coarse-grained	5
6. Limestone, dark gray, weathering light brown, fine-grained, bedding up to 6 inches, 35 percent dark gray bedded chert, unfossilferous.	6
Total	164
Base not exposed.	

fossil remaining balanced on end amid evidence of strong current action.

Numerous colonies of *Lithostrotionella* and *Syringopora* on the large hill are now oriented upside down. It is easy to verify direction of growth on the outcrop by determining normally upwardly convex dissepiments or tabulae in the former case and by noting normally upwardly diverging new corallites in the latter case. The writer did not observe a single colony of either genus right side up among about 20 large colonies for which he determined orientation. Some other colonies, however, seemed equivocal, or necessary features could not be seen. In general, colonies seem to be resting on their convex, calical surfaces, which were directed up in life.

Evidence on orientation of fossils in the western Mississippian hill is meager. Of 11 disassociated single valves of *Perditocardinia* for which orientation could be determined, 7 lay with their concave or

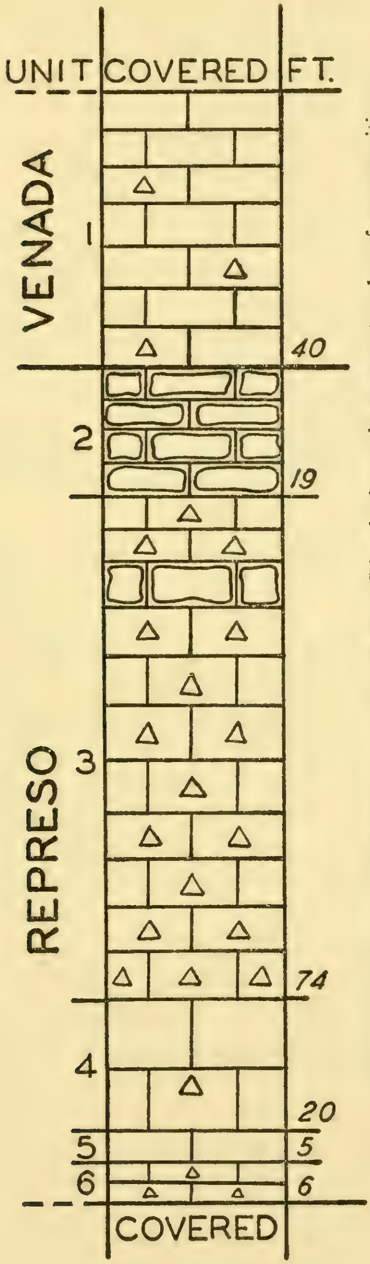

FIG. 2.—Stratigraphic section of Mississippian strata near Bisani, shown in apparent order of superposition.

inner surfaces up and with their convex surfaces down, whereas only 4 single valves were observed to retain the normal orientation of concavo-convex objects in a current-swept environment (that is, with their concave surfaces down).

In view of the evidence presented in the three foregoing paragraphs, the writer concluded that strata in both of these hills are structurally overturned and that apparent dips of 22° to 46° eastward should be interpreted as indicating the western limb of a westerly-overturned anticline. This opinion is not shared by some or possibly even by any other geologists who have studied the field evidence, although about a score of geologists examined the area in late August on excursion A-8 of the XX International Geological Congress. During a discussion of this subject by several paleontologists at section 7 of the Congress in Mexico City in early September 1956, it developed that Dr. C. O. Dunbar definitely established on the excursion that one colony of *Lithostrotionella* is right side up. This evidence, it should be remembered, is in conflict with that revealed by the score or more of colonies studied by the writer, and indicates that both orientations exist. Along these lines, Dr. G. A. Cooper reports (correspondence, January 10, 1956) that elsewhere he has "seen coral heads several feet across overturned with the bottom staring one in the face. This is a common condition in Michigan where there are no structural complications and is simply evidence that the corals lived in rough water then as they do now." The writer had an opportunity to observe the same phenomenon of mixed evidence of coral colonies in Early Permian strata in Nevada, just a few weeks before the above discussions in Mexico. In none of these other instances, however, is the physical evidence so strongly one-sided as it is in the case of the Mississippian strata near Bisani.

Fossils collected by Cooper and Arellano from various beds in the main hill are referred to herein as "undifferentiated" collections. Dr. Cooper informed the writer in conversation that most of the collections came from the cherty strata near the summit of the hill and that he did not collect from strata on the east slope. Those undifferentiated collections, therefore, mostly came from unit 2 of the measured section. Collections made by the writer's party were differentiated as to units 1, 2, and 3 as shown in text figure 2. The presence of the same species of *Perditocardinia* (near *P. dubia*) and of *Caninophyllum sonorense* in unit 1 and in the hills ½ mile west of the main Mississippian hill would indicate that these represent the same stratigraphic unit. Corals and brachiopods from units 2 and 3 were not

found by the writer at the western one of the two Mississippian hills.

By correlating the writer's findings with statements by Cooper (in Weller et al., 1948, pp. 136, 137) and by Cooper and Arellano (1946, p. 610) it seems apparent that the so-called Venada beds with *Perditocardinia* are unit 1 of text figure 2 and the so-called Represo beds with the Kinderhook-Osage fauna are units 2 and 3 and presumably units 4-6 of text figure 2. These names (Venada and Represo) were proposed by Arellano (in Weller et al., 1948, pp. 136, 137) without description or designation of a type locality.

The known range of *Perditocardinia* indicates a late Meramec age for the Venada beds, which would place them in normal position above the Represo beds, which is the way they appear in the outcrop. In this case the various lines of evidence for structural overturning are all invalid in this area. On the other hand, if the physical evidence is valid, then *Perditocardinia* has an earlier range in the Cordilleran region than it has in the midcontinent United States. In view of the conflict of evidence, the writer has adopted the objective viewpoint and has presented the measured section, graphical stratigraphic section (text fig. 2), and index map (text fig. 1) as if the beds are all in normal stratigraphic position. As a matter of opinion, however, the writer thinks that evidence is equally strong that both of the hills are structurally inverted. It is quite probable that this problem will be solved as soon as the meager fauna of the Venada beds is definitely identified to the north in more complete stratigraphic sequences such as are available in Nevada and California.

The corals are nearly all siliceous replacements, although interiors of some of the larger specimens may contain considerable amounts of calcite. Silicification is best nearest the surface, but is generally evident even in the centers of blocks. Replacement is generally complete and homogeneous so that very few specimens are coarsely beekitized. Extensive, partial local silicification of the matrix, where incipient chert nodules are located, has almost obscured morphologic features in some specimens. Fine stringers of quartz or of calcite commonly transect the fossils, causing them in the latter case to fall apart when prepared in an acid bath.

RELATIONSHIPS OF THE FAUNA

Material received by the writer included 188 individual corals or colonies, plus a considerable number of fragments of syringoporoid corals. Of these, 173 specimens are identified. In addition, the collecting party from the University of Southern California obtained 137

additional specimens which were identified plus a few which were not. A list of the 18 species in the coralline fauna from the main locality follows:

Caninia corniculum (Miller) emend. Easton, 1944
Caninia species
Caninophyllum sonorense Easton, new species
Cyathaxonia cordillerensis Easton, new species
Cystelasma invaginatum Easton, new species
Koninckophyllum species
Lithostrotionella confluens Easton, new species
Neozaphrentis tenella (Miller), 1891
Pleurodictyum subramosum Easton, new species
Rotiphyllum occidentale Easton, new species
Rotiphyllum vesiculosum Easton, new species
Syringopora tubifera Easton, new species
Syringopora, new species A
Syringopora, new species B
Triplophyllites (*Homalophyllites*) *circularis* Easton, new species
Triplophyllites (*Homalophyllites*) species
Trochophyllum (*Barrandeophyllum*) species
Trochophyllum (*Trochophyllum*) species

It is apparent from the faunal list that most of the elements are new species. Moreover, five corals identified only as "sp." certainly represent new species, but the material does not justify making types of the specimens. Only two species are assigned to previously known corals. In spite of the apparent scarcity of useful coral species, it is possible to make a reasonable correlation of the Mexican corals with some corals in the standard Mississippian section of the midwestern United States.

Consider first the two previously described species.

Caninia corniculum (Miller) emend. Easton is abundant in the Chouteau limestone of Missouri and Illinois but also occurs in the Pierson limestone and St. Joe limestone (both of Osage age in Missouri), and at other localities of uncertain stratigraphic position, although within the limits of the beds cited (Easton, 1944, p. 50).

Neozaphrentis tenella (Miller) is common and abundant in the Pierson formation of earliest Osage age. It also is known from the Chouteau limestone at the Kinderhook-Osage boundary in Missouri.

Consider next the new species:

Rotiphyllum occidentale is related to *Rotiphyllum hians* in lower and upper parts of the Chouteau limestone (unrestricted) of Missouri. *R. occidentale* occurs commonly in the Great Basin of the

United States in association with *Spirifer centronatus*[4] of Kinderhook-Osage range.

Rotiphyllum vesiculosum is at present a stratigraphically insignificant relative of *R. occidentale.*

Triplophyllites (*Homalophyllites*) *circularis* is closely related to *T.* (*H.*) *pinnatus* (Easton), 1944. The latter species occurs in the upper part of the Chouteau limestone (unrestricted) of Missouri (Easton, 1944, p. 44), which may indicate a possible Osage age for the new species. Other species range in age from upper Kinderhookian into the Osage, and some occur even in upper Meramec strata. The younger species, however, are flattened on the convex side, so this species very probably indicates Kinderhook age.

Lithostrotionella confluens belongs to a genus whose stratigraphic range in North America has not been accurately determined. Until fairly recently, *Lithostrotionella* (*Lithostrotion* of authors) has been considered an index of upper Meramec strata, namely, St. Louis and St. Genevieve limestones. It is now known to occur well down in the Osage series. There is no practical similarity between *L. confluens* and *Lithostrotion microstylum* White, from the Chouteau limestone, which is the only related Kinderhookian coral.

Cyathaxonia cordillerensis is very closely related to *C. tantilla* from the Chouteau limestone and from various other formations near the Kinderhook-Osage boundary in the Mississippi River Valley.

Caninophyllum sonorense is related to *C. incrassatum* from the Redwall limestone and *C. sedaliense* from near the Kinderhook-Osage boundary in Missouri. Similar corals occur abundantly in the Monte Cristo formation and correlative strata in the Great Basin, but the systematics of these western cyathophyllid corals has not been worked out yet.

Cystelasma invaginatum is an odd form not very closely related to other known species. It seemingly is more primitive than species from the Salem limestone of Indiana.

Pleurodictyum subramosum is simply another species in a genus of long range and uncertain stratigraphic value.

Syringopora tubifera has the same faults as the next preceding species, in addition to which a revision of the syringoporoid corals is long overdue. It is not of great stratigraphic importance at present.

Consider next the corals identified as "species":

Caninia species is not well enough preserved to make it very useful.

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[4] Called *Cyrtospirifer? latior* (Swallow) by Sanders.

It has no known close relatives in North American Mississippian faunas.

Trochophyllum (*Trochophyllum*) species is rather closely related to the only other known species *Trochophyllum* (*T.*) *declinis* (Miller), from the Keokuk beds of Indiana.

Trochophyllum (*Barrandeophyllum*) species belongs to a subgenus not previously reported from North America, to the writer's knowledge. The genotype of *Barrandeophyllum* occurs in the lower Middle Devonian of Bohemia and other species are known from Russian strata equivalent to some of the lower Iowan beds in North America.

Triplophyllites (*Homalophyllites*) species, *Syringopora,* new species A, and *Syringopora,* new species B are not diagnostic of subdivisions within their late Paleozoic coralline genera.

Koninckophyllum species is not very close to the lower Mississippian *K. glabrum* from Missouri and so is of uncertain significance at present, other than to indicate a general relationship with Tournaisian-Viséan corals in the European succession.

AGE OF THE FAUNA

Among the various corals known, the following indicate an age transgressing the Kinderhookian-Osagian boundary, in other words, roughly the age of the Chouteau limestone (unrestricted) and the Pierson formation of Missouri: *Caninia corniculum, Rotiphyllum occidentale, Triplophyllites* (*Homalophyllites*) *circularis, Trochophyllum* (*Barrandeophyllum*) species, *Cyathaxonia cordillerense,* and *Neozaphrentis tenella. Trochophyllum* (*Trochophyllum*) species and possibly *Lithostrotionella confluens* and *Cystelasma invaginatum* indicate an age younger than Chouteau. *Caninophyllum sonorense* might indicate either Lower or Middle Mississippian age. Where the writer has observed corals of this sort most commonly in the Great Basin, they are generally pre-Meramec, as in the Dawn Limestone member of the Monte Cristo limestone. A much larger form occurs in the Yellowpine member of supposed Meramec age in southern Nevada.

The type Mississippian sections are not yet known well enough to permit accurate correlation of the Sonoran beds with them on the basis of corals. For instance, when Easton published a review of the Chouteau corals (1944) the precise stratigraphic positions from which each of the types came was not determinable in most cases. Accordingly, much of the fauna was assigned to the Chouteau limestone, unrestricted, and was considered to span the Kinderhook-Osage boundary. Subsequently efforts have been started to re-collect the strata and to

establish the ranges of the species on the basis of new collections referred to current stratigraphic usage. The first results of this important work (Beveridge and Clark, 1952, pp. 72, 76; Spreng, 1952, p. 84) indicate to those authors that the Chouteau should be raised to group rank and that its components, the Compton, Sedalia, and Northview formations, all should be referred to the Kinderhook series. They place the Kinderhook-Osage boundary at the base of the Pierson limestone. As published by Spreng (1952, p. 84) the lower Pierson fauna contains the Osage forms *Caninia corniculum, Neozaphrentis tenella, Cyathaxonia tantilla, Triplophyllites* (*Homalophyllites*) species, and *Caninophyllum* (*Vesiculophyllum*) *sedaliense,* which indicate relationships with the Sonora fauna. Moreover, the Fern Glen is considered by Beveridge and Clarke (1952, p. 76) to be correlative with the Pierson, and therefore the presence of *Cyathaxonia* in the Fern Glen lends additional weight to assigning the Sonoran strata a basal Osage age, at least in part. A revised Kinderhook range chart of species has not been published, so it is not possible now to make an evaluation of how much, if any, of the coralline population is also of Kinderhook age. In any case, the evidence indicates that the Sonoran corals are about at the Kinderhook-Osage boundary and are most probably basal Osage.

The Dawn limestone member of the Monte Cristo limestone carries some of the same species as does the Mississippian section near Bisani. *Lithostrotionella confluens, Triplophyllites* (*Homalophyllites*) *circularis, Rotiphyllum occidentale,* and brachiopods such as *Spirifer centronatus, Schizophoria, Rhipidomella,* and *Spirifer* cf. *S. logani* are noteworthy in both formations. The writer has encountered the foregoing association of species in Mississippian strata over much of the Great Basin of the western United States, but so far the fanua has only been cited infrequently, and then only in part (Hazzard, 1954a, p. 883; 1954b, p. 28). The best place to collect this fauna, insofar as the writer knows, is on the east side of the northern Nopah Range in southeastern California. There, in Hazzard's measured section G-G' (Hazzard, 1937, pp. 274, 275, 332, 333; 1954a, p. 883) the Dawn limestone member is 350 feet thick. It is in normal stratigraphic succession above the Sultan limestone (Devonian) and beneath the Anchor limestone member of the Monte Cristo formation (Mississippian). The fauna is almost equally well represented in the Providence Mountains of California (Hazzard, 1954b, p. 28) where the Dawn and Anchor limestone members are not readily separable. Unpublished information available to the writer indicates that the

fauna also occurs in Nevada in the Joana limestone member of the White Pine shale (where *Rotiphyllum, Caninophyllum,* and *Lithostrotionella* are common), the Bristol Pass limestone, and the Rogers Spring limestone; in Utah in the Midridge limestone; and in Arizona in the Redwall limestone. Owing to uncertainties about the precise ranges of the species in the Cordilleran region, the foregoing formations may not be all of the same precise age. The Redwall limestone, for instance, is almost certainly a bit younger in part than are the other formations (Easton and Gutschick, 1953, p. 9). The approximate relationship of these various formations has been shown elsewhere (Eastern Nevada Geological Association, 1953, pp. 146, 147).

GEOGRAPHIC RELATIONSHIP OF THE FAUNA

The collection at hand contains elements of all three Carboniferous facies faunas recognized by Hill (1948, pp. 121, 142, 143)—the *Cyathaxonia,* compound, and caniniid-clisiophyllid faunas.

Noticeably absent from the collection are *Cleistopora* and *Palaeacis.* Some species of these genera are characteristic of equivalent strata in the Mississippi Valley, in western Europe, and in Australia. Also lacking but characteristic of and common in the equivalent beds of the Mississippi Valley are any species of *Clinophyllum,* calceolid *Homalophyllites,* and *Microcyathus.* The presence of abundant *Triplophyllites* (*Homalophyllites*), of rather common *Rotiphyllum,* and of rare *Neozaphrentis* and *Cyathaxonia* signify a distant connection with the Mississippi Valley seas. The species of *Trochophyllum* signify relationships not only with Russian and Chinese seas but also with English seas all of the same general age.

The presence of Osage *Lithostrotionella,* and of *Caninophyllum, Rotiphyllum,* and *Homalophyllites* links the Sonoran deposits with other deposits in and bordering the Cordilleran geosyncline in California, Nevada, Utah, and Arizona.

In summation, the Mexican coral fauna is an isolated population consisting of (1) some ubiquitous genera, (2) a few elements characteristic of strata in the Mississippi Valley transgressing the Kinderhook-Osage boundary, (3) some elements occurring as far east as western Europe, (4) some elements from the western United States, and (5) some elements occurring as far west as central Russia, eastern China, and Australia.

SYSTEMATICS

Phylum COELENTERATA

Class ANTHOZOA

Order TETRACORALLA

Family CYATHAXONIDAE

Genus CYATHAXONIA Michelin, 1847

CYATHAXONIA CORDILLERENSIS Easton, new species

Plate 1, figures 14, 17, 18

Diagnosis.—*Cyathaxonia* measuring about 10 mm. in length by 3 mm. in calical diameter, with 32 spinose septa in adult stages.

Externals.—Small, curved, ceratoid corals. Theca with septal grooves and encircling striae. Apical angle 25°. The cardinal septum is on the convex side of the coral.

Calyces.—One specimen (a paratype, pl. 1, fig. 17; diameter 2.5 mm. by 3 mm.) has 33 subequal septa in an evenly concave calyx. One order of septa is slightly shorter than the other. The columella is long, circular in cross section, and tapers to a point. Other details obscured with matrix.

The holotype (pl. 1, figs. 14, 18; diameter 3.5 mm. by 4 mm.), probably in late maturity, has 36 long septa arranged in pairs; one septum of each pair here and there seems to be clearly contingent upon the cardinal side of the next septum. The counter position is marked by axial fusion of three septa. Alar septa are indistinguishable from the other major septa, but the loculus on the counter side of each septum is very slightly wider than the neighboring loculi. There are four groups of septa in each quadrant. At the position of the very short cardinal septum is a large space which has every appearance of a fossula but may be the result of faulty preservation. The columella is thickest where joined by the septa, but at its terminus is free, smooth, and oval in cross section. Tabulae and septal spines not observed.

Four paratypes in the U.S.C. collection are about 10 mm. long and are about 3.0 mm. in diameter at the calyx. One of these has seven septa in each quadrant, plus the cardinal, counter, and two alars. Three have 32 septa and one has 28 septa. The calyx is 2.0 mm. deep and the boss stands 0.7 mm. above the calical floor. No cardinal fossula is present. Septa are spinose.

One incomplete paratype in the U.S.C. collection is now 17 mm.

long and was probably over 20 mm. long when complete. It is 3.5 mm. in diameter at the calyx and has 32 spinose septa. Spines are arranged in rows which are inclined apically at about 15° to the axis.

Comparison.—*C. cordillerensis* differs from *C. tantilla* (Miller), which it most closely resembles, in having 32 septa in mature stages instead of having 28 or fewer septa. The species are similar in size, diameter, apical angle, and epithecal features.

C. arcuata Weller, as reviewed by Conkin and Conkin (1954, p. 215), is twice as large as *C. cordillerensis,* and has more septa (34 to 36) as an adult. Inasmuch as Conkin and Conkin report the absence of spines in *C. arcuata,* it is notably different from *Cyathaxonia tantilla* and *C. cordillerensis,* and should be placed in some other genus, possibly new.

Occurrence.—Unit 2, 1 specimen. Unit 3, 4 specimens. Undifferentiated units, 2 specimens.

Material.—Holotype, U.S.N.M. 127950; figured paratype, 127951; 4 paratypes, U.S.C. 4060; 1 paratype, U.S.C. 4061.

Family LACCOPHYLLIDAE

1928. Laccophyllidae GRABAU, Pal. Sinica, ser. B., vol. 2, fasc. 2, p. 82.
1938. Laccophyllidae PRANTL, Ann. Mag. Nat. Hist., ser. 11, vol. 2, No. 7, p. 20.

Remarks.—Prantl's work is the best to date on the family and should be consulted for details. Numerous taxonomic problems concerning laccophyllids cannot be solved until further study of genotypes is made.

Gorsky (1932, p. 87) considered *Laccophyllum, Alleynia,* and *Barrandeophyllum* "seemingly identical." Butler (1935, p. 118) considered *Alleynia, Laccophyllum,* and *Syringaxon* to be possibly synonymous. Butler's view was followed by Lang, Smith, and Thomas (1940, p. 129) who state without reservation that the generic names are synonymous. Prantl (1938, p. 21) considered *Alleynia* and *Syringaxon* to be synonymous but he reserved opinion on *Laccpohyllum.* Even if all the above names are synonyms and *Syringaxon* is the prior genus, there is still some doubt as to the position of *Metriophyllum,* which may be a senior synonym of *Syringaxon.* Lastly, *Ptychocyathus* has priority over all other names, but an appeal has been made to the International Commission of Zoological Nomenclature to suppress Ludwig's genera. So far as is known to the writer, the Commission has not yet acted. In summary, then, there is strong reason to believe that the family name should be based upon either *Syringaxon, Metriophyllum,* or *Ptychocyathus.* The *Laccophyllidae* as used here may

eventually prove to contain the Lindstroemiidae Pocta, 1902, and the Metriophyllidae Hill, 1939. In any case, there is nothing to be gained by changing the family name now with so many uncertainties apparent.

Systematically, the writer considers the family provisionally to contain three homoeomorphic groups. The first of these is typified by *Laccophyllum,* the second by *Trochophyllum,* and the third by *Laccophyllum cyathaxoniaeformis* Gorsky.

Genus **TROCHOPHYLLUM** Milne-Edwards and Haime, 1850

1850. *Trochophyllum* Milne-Edwards and Haime, a Monograph of the British Fossil Corals, Pt. I, p. lxvii. Palaeont. Soc.
1851. *Trochophyllum* Milne-Edwards and Haime, Mus. Hist. Nat., Arch., vol. 5, pp. 166, 356.
1935. *Crassiphyllum* Grove, Amer. Midl. Nat., vol. 16, No. 3, p. 368.
1940. *Trochophyllum* Lang, Smith, and Thomas, Index of Paleozoic coral genera, p. 135. British Mus. (Nat. Hist.).
1944. *Permia* Hudson, Journ. Paleont., vol. 18, No. 4, p. 359 [in part].
1948. *Trochophyllum* Stumm, Journ. Paleont., vol. 22, No. 1, p. 71.

Diagnosis.—Small, ceratoid, curved or geniculate, simple corals. Epitheca smooth, striate, pseudocostate, or with septal grooves. Calyx inverted, moderately deep, Septa in one or two orders, most meeting at or forming an axial tube. Tabulae may be in two orders, those in the axial tube constituting "inner tabulae," and those in loculi constituting "outer tabulae."

Genotype.—*Trochophyllum verneuli* Milne-Edwards and Haime, 1850, p. lxvii, by original designation.

Occurrence.—The genotype was collected by de Verneuil from the hills 7 miles south of Louisville, Ky. These beds have been well-known collecting grounds for fossils from the New Providence shale in the Keokuk portion of the Mississippian period.

Remarks.—The writer considers it advisable to apply and extend Hudson's broad interpretation of *Permia* (to the same corals but under the name *Trochophyllum*) for several reasons, namely (1) the convergence of structure in several lines of development does indicate that *Trochophyllum* can be used as a composite genus; (2) at the present time only a few species are known and these are not adequate for evolutionary purposes; (3) stratigraphic usefulness is enhanced by having fewer narrowly restricted genera to consider.

Even so, the significant variations known to occur warrant some subdivision of *Trochophyllum;* therefore, the writer proposes a new arrangement of these groups under the genus *Trochophyllum.*

Much confusion exists regarding tabulae and dissepiments in

Permia and related subgenera. The tendency in the literature has been to refer to the skeletal elements in loculi as dissepiments. Apparently by so doing, Grabau, Grove, and Hudson have avoided any inference that the aforementioned structures extend across the entire calyx as would typical tabulae. On the other hand, it should be pointed out that the "dissepiments" referred to by these writers resemble the dissepiments of other corals less than they resemble tabulae of other corals. For example, typical dissepiments are convex axially and are arranged in series sloping from the epitheca proximally and axially, whereas the "dissepiments" mentioned above slope from the axial region proximally and peripherally. There seems to be no disagreement about horizontal skeletal elements within the central tube—these are termed tabulae. In order to clarify the terminology, the writer proposes that the horizontal skeletal elements within the tube be referred to as "inner tabulae" and the elements sloping down to the epitheca from the axial region be termed "outer tabulae."

Stuckenberg (1895) does not refer to tabulae or dissepiments in his generic and specific descriptions of *Permia* and *P. iwanowi,* but his figure 6d on plate 3 shows some transverse structures in loculi near the lower right edge of that specimen that might be transverse skeletal structures.

The central tube seems generally to be formed of the fused inner ends of the septa with addition of stereoplasm. As such it may be technically termed a stereotheca, but unless details of microscopic structure are discernible, this feature cannot be recognized; therefore, the writer uses the looser terminology "axial tube."

Subgenus TROCHOPHYLLUM Milne-Edwards and Haime, 1850

[Synonymy the same as for the genus.]

Diagnosis.—*Trochophyllum* with a nontabulate axial tube, only one (major) order of septa, the weakly or strongly developed cardinal fossula on the convex side when corals are curved, outer tabulae present in the loculi, septal grooves usually absent, and stereoplasm deposited on the axial tube.

Type.—Same as for the genus.

Occurrence.—The occurrence is the same as for the genotype.

Remarks.—Included here are *Trochophyllum* (*Trochophyllum*) *declinis* (Miller), *Trochophyllum* (*T.*) species described in this paper, *Trochophyllum* (*T.*) *choniukounense* (Grabau) [=*Barrandeophyllum choniukounense* Grabau], *Trochophyllum* (*T.*) *compressum* (Grabau) [=*Barrandeophyllum compressum* Grabau], and probably

Trochophyllum (*T.*) *disjunctum* (Grabau) [=*Barrandeophyllum disjunctum* Grabau].

TROCHOPHYLLUM (TROCHOPHYLLUM) species

Plate 1, figures 13, 21

Externals.—Medium size, curved geniculate, ceratoid, measuring 20 mm. in length. The theca is smooth except for rugae. A long oblique scar of attachment is present at the apex. Apical angle is 35°.

Calyx.—The calyx (diameters 9.5 mm. by 8.5 mm.) is shallow with the distal ends of the septa sloping down toward the calyx floor. There are 25 major septa of about equal length for one very short one and two or three on either side of it which become progressively longer. This deep depression on the convex side of the coral is assumed to be the cardinal fossula. This interpretation is borne out by the character of the sixth septa on either side of the short cardinal septum, which are contratingent against the seventh septa. Septa of the cardinal quadrants are radially arranged, whereas those of both counter quadrants are flexed counterclockwise. Minor septa are not present.

The axial tube is a thin subcircular cylinder which rises 2 mm. or more above the floor of the calyx. The outer surface of the axial tube bears here and there the traces of septa or of tabulae, but there is no surficial indication that it is composed of fused skeletal elements. Internally, the axial tube is nontabulate; indeed, its interior walls are quite smooth down a distance of perhaps 10 mm. where the bending of the coral carries the tube out of sight.

Tabulae are present in the cardinal quadrants; they are very steeply inclined and may be confused with septa because they also are directed counterclockwise. Tabulae are also indicated by horizontal traces on the inside of the theca.

Dissepiments were not observed but rejuvenation resembles broad dissepimental structure where a new inner theca has been deposited and older portions of the calyx sealed off.

Occurrence.—Undifferentiated, 1 specimen.

Material.—U.S.N.M. 127949.

Subgenus BARRANDEOPHYLLUM (Pocta) Easton, new combination

1902. *Barrandeophyllum* Pocta, *in* Barrande, Syst. Silur. du Centre de la Boheme, vol. 8, t. 2, p. 190.

Diagnosis.—*Trochophyllum* with inner tabulae in the axial tube which may expand rapidly, two orders of septa, outer tabulae present in the loculi, septal grooves present, and little or no stereoplasmic thickening of the axial tube.

Type.—*Barrandeophyllum perplexum* Pocta, 1902.

Occurrence.—Lower Middle Devonian of Bohemia.

Remarks.—Included here are *Trochophyllum* (*Barrandeophyllum*) *perplexum* (Pocta), *Trochophyllum* (*B.*) species described in this paper, and *Trochophyllum* (*B.*) *turbinatum* (Gorsky) [=*Laccophyllum turbinatum* Gorsky].

TROCHOPHYLLUM (BARRANDEOPHYLLUM) species

Plate 1, figures 19, 23

Externals.—Small, curved, ceratoid, measuring 8 mm. in length. Theca without interseptal ridges but with encircling rugae. Apical angle 25°. Apex marked by oblique scar of attachment.

Calyx.—The calyx (diameter 3.5 mm.) is moderately deep and vertically walled. The 16 major septa are radially arranged and terminate at the axial tube. These septa are equally spaced, except for four which almost meet the tips of four others at the axial tube; this distribution appears to be fortuitous, rather than being related to the basic plan of septal insertion. Short minor septa alternate with the major septa.

The axial tube consists of a tabulate tube lying halfway to the axis from the theca. Most of the major septa terminate at right angles against it and there is no external indication that it is formed of the bent inner ends of the septa. The axial tube is subcircular in cross section, actually being subtley pentagonal in the specimen at hand. The density of packing of tabulae within the axial tube is not known. Outer tabulae are quite closely spaced between the axial tube and the theca, being steeply arched distally to where they meet the axial tube.

Occurrence.—Undifferentiated, 1 specimen.

Material.—U.S.N.M. 127952.

Remarks.—There being but one specimen, it was not sectioned. Further details may be furnished by study of additional material collected in the future, but at present there would be nothing gained by giving this specimen a new name.

As far as is known to the writer, this is the first time that *Barrandeophyllum* has been reported from the Mississippian of North America. Although the specimen has no value in detailed correlations, it affords a bit of evidence as to the geographic distribution of Mississippian faunas.

Subgenus PERMIA Stuckenberg, 1895

1895. *Permia* Stuckenberg, Mém. Com. Géol., vol. 10, No. 3, pp. 26, 186.
1928. *Permia* Grabau, Pal. Sinica, ser. B, vol. 2, fasc. 2, p. 95.

1940. *Permia* LANG, SMITH, AND THOMAS, Index of Palaeozoic coral genera, p. 97. British Mus. (Nat. Hist.).

1944. *Permia* HUDSON, Journ. Paleont., vol. 18, No. 4, p. 359.

Diagnosis.—Trochophyllum with a nontabulate axial tube, two orders of septa, the cardinal fossula weakly or strongly developed and lying on the convex side of the coral when the coral is curved, outer tabulae in the loculi, septal grooves usually present, and the axial tube thickened with stereoplasm.

Original diagnosis.—"Solitary corals having slightly curved cups in the shape of a small horn, of fairly large size.[5] Columella occupying a space in the central part of the cup, of fairly large size, tubelike and hollow. Septa in two generations. The cardinal septum is shorter than the other septa of the first order and is inserted in a fossula. Other septa of that order reach the columella and they alternate with shorter septa of the second order." (Free translation of the Russian text.)

Genotype.—Permia iwanowi Stuckenberg, 1895, pp. 27, 187, pl. 3, figs. 6a-6g. The holotype and paratypes of *P. iwanowi* were designated by Hudson (1944, p. 359). For an English translation of Stuckenberg's description of the genotype, with corrections from the published figures, see Hudson (1944, pp. 359, 360).

Occurrence.—The genotype is from the Lower Carboniferous of the west slope of the Urals, on the Gubacha River round about the village of Gubacha (otherwise known as Ivanoff) in the Perm district.

Remarks.—Hudson (1944) referred the first new species to *Permia* since Stuckenberg's work. Included here are *Trochophyllum* (*Permia*) *iwanowi*, *Trochophyllum* (*P.*) *caverna* Hudson, and *Trochophyllum* (*P.*) *carbonaria* Hudson.

Subgenus not named

1932. *Laccophyllum* GORSKY, Trans. Geol. Prosp. Serv., U.S.S.R., fasc. 51, p. 6 [in part].

Diagnosis.—Trochophyllum with inner tabulae in the axial tube, septa of one order, outer tabulae present in the loculi, and the axial tube thickened by stereoplasm.

Remarks.—If *Trochophyllum turbinatum* (Gorsky) [=*Laccophyllum turbinatum* Gorsky] has just one order of septa, then it would belong in this subgenus. As it stands, Gorsky (1932, p. 68) says two

[5] The German text (p. 186) has an extra sentence at this point not contained in the Russian text; namely, "The calyx is circular."

septa "bifurcate at the periphery," but one cannot be sure if this signifies that two major septa or a major and a minor septum are involved in each case.

Family METRIOPHYLLIDAE

Genus ROTIPHYLLUM Hudson, 1942

Remarks.—For a diagnosis see Hudson, 1942, or Easton, 1944. The material under study shows well-developed alar pseudofossulae, hence the generic diagnosis should be changed from "alar fossulae indistinguishable from other loculi" (Hudson, 1942, p. 257) to alar fossulae either indistinguishable or present as pseudofossulae with each alar septum contratingent against the adjacent counter septum and occupying an extra wide loculus axially.

ROTIPHYLLUM OCCIDENTALE Easton, new species

Plate 1, figures 1-3

Description.—A mature specimen (the holotype, pl. 1, figs. 2, 3; diameters 6 mm. by 7 mm.) has 26 major septa alternating with an equal number of short minor septa. The columella is thin and tall. The cardinal septum extends across the fossula below the calyx floor, but retreats distally.

Another mature specimen (width of calyx 6 mm.) has 24 major septa plus alternating minor septa. The columella is narrowly elliptical. Traces of tabulae can be seen along the fractured edge of the specimen.

In a specimen in early maturity or late youth (pl. 1, fig. 1; diameter 4.5 mm. by 5 mm.) there are 24 major septa but no minor septa. The cardinal fossula is as in later stages, the counter septum extends farther distally than in later stages, and alar pseudofossulae can be distinguished as large, long loculi. The columella is narrowly elliptical.

Another specimen in late youth (diameters 4 mm. by 4 mm.) has 20 major septa, 4 of which have just been inserted. The columella is narrowly elliptical.

A paratype (U.S.C. 4066) in late maturity is 14 mm. long and has calical diameters of 8.8 mm. by 9.1 mm. The apical angle is 35°. Septal grooves are faint. The cardinal fossula is on the convex side of the corallite and is keyhole-shaped (axially swollen). The calyx slopes toward the counter side and apically at 35° and is 4 mm. deep. The short cardinal septum is bordered by 6 majors plus the alar

septum in each quadrant, and the long counter septum is also bordered by 7 majors, the total being 30 major septa. Rudimentary to short minor septa alternate with the majors. Alar pseudofossulae are distinct. The columella at the axial end of the counter septum extends slightly into the cardinal fossula and stands up 2 mm. from the floor of the calyx.

Another paratype (U.S.C. 4063) is attached along its cardinal side to a brachiopod shell for a distance of about 10 mm.

The most advanced stage seen (U.S.C. 4066) has 35 major septa at a calical width of 10.3 mm.

Comparison.—*Rotiphyllum occidentale* differs from *R. hians* Easton, 1944, in having slightly more septa at comparable stages, a thinner columella above the calical floor, and a deeper and less flaring calyx. The two species resemble each other rather closely, however.

Occurrence.—Unit 3, 22 specimens; unit 2, 1 specimen; unit 1, 2 specimens; undifferentiated, 6 specimens.

Material.—Holotype, U.S.N.M. 127946; paratypes, U.S.N.M. 127947, U.S.C. 4066, and 4063; topotypes, U.S.N.M. 137146, and U.S.C. 4062 and 4064.

Remarks.—In summation, there is no evidence that minor septa are inserted until after all the major septa are present. The evenly expanding calyx, therefore, continues to maintain the apical angle (about 45°) by insertion of minor septa in late maturity. The stage of old age may be said to commence when the calyx ceases to expand and the spaces between major and minor septa become equal. The columella changes its cross section from narrowly elliptical in early stages to thin and bladelike in late stages.

ROTIPHYLLUM VESICULOSUM Easton, new species

Plate 1, figure 25

Description.—*Rotiphyllum* resembling *R. occidentale* but having dissepiments.

The holotype, U.S.C. 4067, is a fragment 20 mm. long with a circular calyx 11 mm. in diameter. The prominent cardinal fossula is on the convex side of the coral and is slightly swollen axially. The cardinal septum is very short in the calyx but extends across the floor of the cardinal fossula and runs up the side of the columella as a prominent ridge. The calyx contains 31 major septa, of which 8 (including the alar septa) are in each cardinal quadrant. The counter septum is not clearly distinguishable. The columella is prominent, being 1 mm. thick and 3 mm. wide and standing 3 mm. above the calical floor. Dis-

sepiments are lacking in a narrow zone on the counter side, but occur in as many as five ranks on the cardinal side. Most are concentric, but several lonsdaleoid dissepiments clearly span two or three septa. Minor septa are sparse and only occur in the outer region of the thickest dissepimentarium. Tabulae are not discernible.

The paratype, U.S.C. 4068, is 9 mm. in diameter at the calyx and has 31 rather radially arranged major septa. The cardinal septum is as in the holotype, but the counter septum is attached to the prominent columella in typical lophophyllid fashion. One rank of concentric dissepiments occurs in the right cardinal quadrant. Minor septa occur between all majors and traverse the dissepiment. Tabulae arch up steeply and then are depressed around the columella so that they make a horseshoe-shaped mound around the axial region.

Comparison.—*R. vesiculosum* resembles *R. occidentale* Easton in all features except that the former species possesses dissepiments. In this same respect it differs from all other *Rotiphyllum.*

Occurrence.—Unit 3, 2 specimens.

Material.—Holotype, U.S.C. 4067; paratype, U.S.C. 4068.

Remarks.—The presence of tabulae would ordinarily be sufficient to separate this species from *Rotiphyllum,* yet the two specimens at hand seem clearly to be merely extreme variations of *R. occidentale* with which they occur. If a population is discovered in which the specimens are consistently dissepimented, then a new genus should be made for them. At present this procedure is unwarranted, particularly in view of the known tendency of zaphrenthid corals to develop a trend toward dissepiments.

Family HAPSIPHYLLIDAE

Genus TRIPLOPHYLLITES Easton, 1944

Subgenus HOMALOPHYLLITES Easton, 1944, emended 1951

HOMALOPHYLLITES REVERSUS species group, Easton, 1951

TRIPLOPHYLLITES (HOMALOPHYLLITES) CIRCULARIS Easton, new species

Plate 1, figures 4, 7-9

Externals.—Small to medium-sized, curved, ceratoid, measuring up to 22 mm. in length but averaging 10 mm. to 15 mm. Apical angle 25° to 30°. Theca with rugae and striae but rarely with septal grooves. Two paratypes, U.S.N.M. 127945e, have girdlelike epithecal indentations or constrictions.

Calyces.—Calyx of holotype (diameters 7 mm. by 7 mm.) in late maturity has 31 major septa, all but 5 of which terminate around an

axially enlarged cardinal fossula, forming a solid fossular wall. The cardinal septum is even shorter than either of the adjacent short major septa in the fossula. Minor septa extend one-fourth of the radius and alternate with the major septa, except at the alar and cardinal positions. Minor septa are absent adjacent to the last-formed septum in each counter quadrant. These latter septa resemble minor septa but are longer and are fused with the next adjacent counter septa. Alar pseudofossulae are poorly differentiated, the loculi being no wider than other loculi, but the last-formed counter septa extend less far distally than other majors and hence lie in depressions. The two short septa in the cardinal fossula bordering the cardinal septum are short major septa instead of minor septa. Minor septa are not present on either side of these last-formed major septa in the cardinal quadrants. The cardinal and counter quadrants contain 15 and 16 major septa and 10 and 13 minor septa respectively.

In a paratype, U.S.N.M. 127945a (diameters 6.5 mm. by 6.5 mm.) in late maturity there are 30 major septa distributed essentially as in the holotype. Minor septa are distributed in identical fashion as in the holotype. This specimen is slightly more mature than the holotype and thereby affords an opportunity to determine the order of septal insertion in a late stage. There are 5 major septa in the cardinal fossula; 2 are very short and are present near the periphery of the calyx; 2 are long down in the fossula and eventually would have become longer to add their substance to the fossular wall (as in the holotype).

In a paratype, U.S.N.M. 127945d (diameters 4 mm. by 4 mm.) in middle maturity, there are 24 major septa of which 11 are in the cardinal quadrants. Alar septa do not quite reach the fossular wall and are a little depressed beneath the floor of the calyx; this rudimentary fossula, combined with the usual development of alar pseudofossulae makes a distinctive break in symmetry at the alar positions. The cardinal fossula is slightly swollen axially. Minor septa are very short.

In a paratype, U.S.N.M. 127945c (diameters 3 mm. by 3 mm.) in early maturity, there are 22 major septa, of which 11 are in the cardinal quadrants. Only 19 have been inserted at the level of the calyx floor, however, and the specimen therefore represents a stage somewhat earlier than in U.S.N.M. 127945d. The cardinal fossula is as before; alar position is less well marked than before; the counter septum is bordered by extra wide loculi.

In a paratype, U.S.N.M. 127945b (diameters 2 mm. by 2 mm.)

there are 18 major septa with rudimentary minor septa present at a few places. The cardinal septum is long and extends completely across the large cardinal fossula. Each of the major septa adjacent to the cardinal septum resembles the minor septa. There are 9 major septa on the cardinal side and 9 on the counter side.

Tabulae observed among U.S.N.M. 127945f are steeply convex distally. They are not commonly discernible in calyces and are generally incomplete or at least not present at the same level in all loculi.

Early stages.—The earliest stage observed (diameter about 0.8 mm.), in U.S.N.M. 127945d, has 8 septa. The cardinal quadrants contain 3 and the counter quadrants contain 5 septa. Minor septa are not present.

Comparison.—*T.* (*H.*) *circularis* differs from *T.* (*H.*) *calceolus* (White and Whitfield) in being circular in cross section instead of being flattened on the convex side, and in having longer minor septa. It differs from *T.* (*H.*) *subcrassus* Easton and Gutschick, 1953, in having a thinner theca and fewer septa.

Occurrence.—Unit 3, 26 speciments; unit 2, 8 specimens; unit 1, 2 specimens; undifferentiated, 93 specimens.

Material.—Holotype, U.S.N.M. 127944; figured paratypes, U.S.-N.M. 127945a, b; unfigured paratypes, U.S.N.M. 127945c-g; topotypes, U.S.N.M. 127945, U.S.C. 4069 and 4070.

Remarks.—*T.* (*H.*) *calceolus* becomes increasingly flattened distally. *T.* (*H.*) *circularis,* on the other hand, is evenly circular in cross sections throughout. If there is any phylogenetic significance to the progressive flattening of *T.* (*H.*) *calceolus,* then it would seem that it evolved from an unflattened ancestor. Inasmuch as the two species named above are quite similar in other respects, it is not impossible that *T.* (*H.*) *calceolus* evolved from *T.* (*H.*) *circularis.*

The only other variable character is the length of the minor septa, which are longer in *T.* (*H.*) *circularis* than in the other species. Amplexoid retreat of the major septa is a significant feature of many corals, but it is not known whether a phylogenetic interpretation can be applied to shortening of minor septa. If the two orders of septa behave similarly, then there is substantiating evidence for the possible ancestry of *T.* (*H.*) *calceolus* in *T.* (*H.*) *circularis.*

Further indication of the close relationship between *T.* (*H.*) *circularis and T.* (*H.*) *calceolus* is seen in the presence of epithecal constrictions, which are rare in the former but common in the latter species.

TRIPLOPHYLLITES (HOMALOPHYLLITES) species

Plate 2, figure 7

?1951. *Triplophyllites* (*Homalophyllites*) sp. EASTON, Journ. Paleont., vol. 25, No. 3, p. 399, pl. 61, figs. 8a-8c. Escabrosa limestone, Arizona.

Externals.—Simple, curved, ceratoid coral with the cardinal fossula on the convex side. The cardinal septum is very short and lies in a slightly axially swollen cardinal fossula. In a calyx 16 mm. by 14. mm, 35 radially arranged major septa traverse two-thirds of the radius as vertical plates and then extend across the tabulae as low ridges twisted loosely counterclockwise at the axis. Minor septa are absent or are represented by septal ridges. Tabulae axially depressed. No dissepiments.

Occurrence.—Unit 3, 1 specimen.

Material.—U.S.C. 4170.

Remarks.—This specimen seems to be a little more mature or at least has more and longer septa than does the specimen from Arizona cited above.

TRIPLOPHYLLITES species

Among the few fragments seen, one measuring 8 mm. in diameter has about 30 septa which extend about three-fourths of the radius and are free axially. At a diameter of 13 mm. there are about 45 to 50 major septa, minor septa are lacking, and there is a prominent key-hole-shaped inner wall in conjunction with the cardinal fossula.

Occurrence.—North end of low hill 2 miles west of Bisani, Mexico. This is about 0.5 mile west of the major locality at the lime kilns; 3 specimens.

Material.—U.S.C. 4231.

Remarks.—This sort of coral is common in late Paleozoic rocks.

Genus NEOZAPHRENTIS Grove, 1935

NEOZAPHRENTIS TENELLA (Miller), 1891, emend. Easton, 1944

Plate 2, figure 5

1944. *Neozaphrentis tenella* EASTON, Illinois Geol. Surv., Rep. Inv. 97, p. 45, pl. 4, figs. 1-3; pl. 16, figs. 26-30 (contains prior synonymy).

Externals.—Curved, ceratoid, simple corals with an apical angle of 20°-30° and a circular cross section. Theca with growth lines and occasional concentric ridges and depressions, but septal grooves are

not discernible. Specimens range up to 25 mm. in length. The cardinal fossula is on the concave side of the corallite.

In early neanic stage a calyx 3.3 mm. in diameter contains a short cardinal septum in a V-shaped cardinal fossula; the right cardinal quadrant contains two pinnate majors; the right and left counter quadrants each contain four majors; the counter septum extends slightly into the cardinal fossula; the left cardinal quadrant contains three pinnate majors. Alar pseudofossulae narrow. Trace of a distally convex tabula is visible, but dissepiments and minor septa are absent.

In midephebic stage a calyx at 6.5 mm. width contains a very short cardinal septum and four and five strikingly pinnate majors in the right and left cardinal quadrants, respectively. Each counter quadrant contains seven radially arranged majors. The slightly axially swollen counter septum extends a little past the axis and into the parallel-sided cardinal fossula. Alar pseudofossulae distinct, but dissepiments and minor septa are absent.

In late ephebic stage at a width of 9.0 mm. the cardinal septum extends about one-third of the length of the V-shaped cardinal fossula. Each cardinal quadrant contains five radially arranged major septa and each counter quadrant contains six major septa. The axially swollen counter septum stands higher than the other majors in the calyx and extends to the axis where it occupies an open space formed by the union of the narrow alar pseudofossulae with the cardinal fossula. Minor septa occur as ridges in most loculi. Tabulae slope steeply away from the axial region, particularly steeply into the cardinal fossula. Dissepiments absent.

Occurrence.—Unit 3, 7 specimens.

Material.—Figured hypotype, U.S.C. 4165; unfigured hypotypes U.S.C. 4166 and 4167; other material, U.S.C. 4168.

Remarks.—*Neozaphrentis tenella* is characterized by the long counter septum and by rudimentary or absent dissepiments. *N. tenella* passes through a stage in which the septa of the cardinal quadrants are notably pinnate.

Mature *N. tenella* from the midwest usually contain from 25 to 27 major speta, although as many as 34 major septa have been observed. The material at hand is only known to have up to 24 major septa. This difference is too slight to warrant separation from the well-known midwestern species.

Family CANINIIDAE

Genus **CANINIA** Michelin in Gervais, 1840

CANINIA CORNICULUM (Miller) emend. Easton

Plate 1, figures 5, 6

1944. *Caninia corniculum* (Miller), emend. EASTON, Illinois Geol. Surv., Rep. Inv. 97, p. 49; pl. 12, figs. 1-3; pl. 16, figs. 40-42. (This reference contains prior synonymy.)

Externals.—The specimens at hand illustrate very well the variable nature of this species. Corals range from short, widely flaring examples with an apical angle of 40° through the normal or at least more frequent examples with apical angles of 10° to 15°, and finally into specimens which are subcylindrical. Thecas only rarely show traces of septal grooves, most exteriors being striate, rugose, and contorted all together.

Calyces.—Calyces are moderately deep, with tabulate floors usually horizontal, but also inclined at greater or less angles. Septa are frequently rather sinuous, continue to be inserted during calical growth, and may or may not meet the theca. When dissepiments are observed, two kinds occur—in early maturity broad isolated patches consisting of one large vesicle may be seen; in late maturity the patches become more general and finally overlap to form a lonsdaleoid dissepimentarium three or four vesicles deep in late stages.

In late maturity (diameters 12 mm. by 11.5 mm.) one specimen, U.S.N.M. 127948, has 33 long major septa extending two-thirds of the radius. The cardinal septum is short and in a very deep fossula where the tabulae are steeply invaginated. The counter septum is longer than the other majors. Minor septa short or rudimentary to absent and not present on the surfaces of the innermost dissepiments, although weakly developed on the outer dissepiments and the theca. Dissepiments present in one to three ranks. This specimen is trochoid and 1.5 cm. long (incomplete).

At a slightly later stage, U.S.N.M. 127956a, there are about the same number of septa, but the dissepimentarium has five or six rows of vessicles and minor septa are present on the surface of the innermost row. This specimen is subcylindrical and 4 cm. long (incomplete).

In early maturity a specimen, U.S.N.M. 127956c (diameters 5 mm. by 8.5 mm.) has 25 major septa, 5 of which meet axially. This specimen is elongate in one diameter because of modifications for attachment; a rather carinate ridge extends along this side. A dissepiment

is present at one place and minor septa are present on the theca at that place.

The most advanced stage observed, U.S.N.M. 127956e (diameters 13 mm. by 14 mm.) has 36 major septa. Minor septa and dissepiments are both less well developed than in earlier stages.

Two cylindrical examples, U.S.N.M. 127956f, g (about 10 mm. in diameter) have 22 major septa, with a few minors and no dissepiments observed.

The broken apex of one specimen shows six or eight septa meeting at the axis.

Tabulae.—Tabulae in U.S.N.M. 127956b are about 1 mm. apart or there may be six in 5 mm. They are flat axially and strongly recurved peripherally, being invaginated one inside the next.

Occurrence.—Unit 3, 3 specimens; unit 2, 3 specimens; unit 1, 1 specimen; undifferentiated, 27 specimens.

Material.—Hypotypes, U.S.N.M. 127948 and 127956a-g; other material U.S.N.M. 127956, U.S.C. 4071, 4078, 4079.

Remarks.—*Caninia corniculum* is highly variable, but can be recognized as occurring in two intergrading phases. One of these is the flaring type which will show minor septa and dissepiments in rows in late stages. The other is the cylindrical phase (Easton, 1944, p. 50) which is characterized by amplexoid retreat of the major septa and with few minor septa and sparse dissepiments. Although not always discernible, the slightly sinuous major septa and geniculate habit of growth aid in determinations. If dissepiments and minor septa are not observed, the species converges upon *Amplexus* of authors and cannot be certainly identified without sections. That it is referable to *Caninia* is borne out not only in the morphology of mature calyces, but also in the axial meeting of septa in young stages.

It is not known what significances should be attached to the two extremes of variation. Individuals may be different enough to be termed separate species, but when a suite is available there is no apparent line of demarcation between variations.

CANINIA species

Plate 1, figure 10

Externals.—Slightly contorted ceratoid coral with an apical angle of 35°. The epitheca is nearly smooth, there being only faint encircling irregularities.

Calyx depth not known. At a diameter of 2 cm. there are about 40 septa of equal length, extending two-thirds of the radius. Calyx

floor smooth and flat. Dissepiments occupying about one-half the radius. The outer row or two of dissepiments are lonsdaleoid; the inner rows are concentric.

A rough longitudinal section is observable where etching has destroyed a side of the coral. Tabulae are horizontal or very slightly sagging axially, but are strongly recurved near their peripheries. Dissepiments very steeply inclined.

Occurrence.—Unit 2, 3 specimens; unit 3, 1 specimen; undifferentiated, 2 specimens.

Material.—U.S.N.M. 127953, 127961; U.S.C. 4163, 4164.

Genus CANINOPHYLLUM Lewis, 1929

Remarks.—*Vesiculophyllum* Easton, 1944, was erected for caninioid corals which differ from *Caninophyllum* chiefly in having the dissepimentarium well developed only in late stages. As presently interpreted by the writer, this would be of subgeneric rank; therefore, *Vesiculophyllum* is now considered by the writer to be a subgenus of *Caninophyllum.*

CANINOPHYLLUM SONORENSE Easton, new species

Plate 2, figures 1-4

Description.—These are large solitary corals, curved ceratoid to nearly cylindrical, commonly about 10 cm. long and 3 cm. in diameter at the calyx. Calyces are deep, with four bundles of septa, corresponding to the four quadrants, descending steeply to almost touch pinnately at the axis. Specimens are commonly decorticated, but the theca, where observed, is thin and is only fairly ridged longitudinally.

In transverse section at maturity, diameters 25 mm. by 25 mm., the holotype (pl. 2, fig. 3) has 47 long major septa which are grouped into four distinct pinnate bundles. The right and left cardinal quadrants contain eight and nine major septa, respectively, and the cardinal septum is longer and thinner than the adjacent majors. Septa of the cardinal quadrants are more dilated than are septa of the counter quadrants. The counter side has about three ranks of concentric dissepiments between major and minor septa, and has a narrow peripheral zone of lonsdaleoid dissepiments. Minor septa extend across the dissepimentarium. Major septa are not dilated in the dissepimentarium.

In early maturity, diameters 15 mm. by 15 mm., the holotype (pl. 2, fig. 2) has 36 almost equally dilated septa, of which the cardinal is short. The cardinal quadrants contain six or seven major septa. Only

one or two very short minor septa are discernible, and dissepiments are absent.

In a paratype about 30 mm. in diameter the long cardinal septum in the base of the narrow cardinal fossula retreats upward as the fossula progressively invades the dissepimentarium. Cardinal quadrants contain 9 and 10 long major septa which are grouped pinnately against the cardinal fossula and the alar septa. The counter quadrants, including the counter septum, contain 26 major septa which are grouped in pinnate bundles which almost reach the axis. The dissepimentarium extends one-half to two-thirds of the radius in some places. Minor septa barely reach the inner edge of the dissepimentarium.

Another paratype at a diameter of about 25 mm. has about 50 major septa in pinnate groups. It has lonsdaleoid dissepiments in the margin of a dissepimentarium which extends about half of the radius.

In longitudinal section the tabulae occur irregularly about 10 in 2 cm., are commonly incomplete, and may be slightly concave, or slightly convex. Dissepiments are quite elongate and nearly vertical, being about 4 or more times as long as wide.

In transverse section dissepiments usually appear concentric but a few angulo-concentric instances are present. Lonsdaleoid dissepiments are uncommon but are present.

Comparison.—This species differs from *C. incrassatum* Easton and Gutschick, 1953, in having only rudimentary minor septa even into late maturity and in having concentric dissepiments instead of herringbone dissepiments. The dissepimentarium of *C. sonorense* is generally narrower than than of *C. incrassatum.*

C. sonorense differs from *Caninophyllum sedaliense* (White), 1880, in having a much narrower dissepimentarium, longer and more quadripartite groups of major septa, and shorter minor septa.

Occurrence.—Unit 1, 35 specimens. North end of small hill 2 miles west of Bisani, Mexico, 1 specimen.

Material.—Holotype, U.S.C. 4225; paratypes, U.S.C. 4179, 4224, 4226, 4229; topotypes, U.S.C. 4171, 4172, 4222, 4227, 4228, and U.S.N.M. 127959.

Family CLISIOPHYLLIDAE

Genus KONINCKOPHYLLUM Thomson and Nicholson, 1876

KONINCKOPHYLLUM species

Plate 2, figure 6

Externals.—Simple, curved, ceratoid corals with an apical angle of about 30°. Cardinal fossula on the convex side of the corallite. Theca with concentric striae and irregularly placed constrictions, and faint

septal grooves. The figured specimen is 22 mm. long and is circular in cross section.

A calyx at a diameter of 13.0 mm. is 6 mm. deep but has a very large, broad, conical boss in the axial region which stands 3 mm. above the calical floor. Calical walls are essentially vertical. The cardinal septum is a ridge in the slightly swollen cardinal fossula. Each cardinal quadrant contains 10 major septa and the counter quadrants together with the indistinguishable counter septum contain a total of 23 major septa. Dissepimentarium narrow (1 or 2 mm. wide) and traversed by the cardinal fossula and by the thin minor septa which stop at the axial or inner end of the dissepimentarium. Dissepiments seemingly concentric. Axial structure seemingly consists of tentlike tabulae and minor septa fused to an axial rod, and all reinforced by extensive stereoplasm. Locally septa may merely lie upon upper surfaces of tabulae. Lamellae and tabellae absent.

Silicification has obscured details on the one cut surface prepared.

Occurrence.—Unit 1, 2 specimens.

Material.—U.S.C. 4169.

Remarks.—Lower Carboniferous strata elsewhere often abound in clisiophyllid corals, but the writer has not discovered in the United States a species closely resembling this one from Sonora. It has longer, tapering majors, more tentlike tabulae, and narrower dissepimentarium than has typical *Koninckophyllum. Koninckophyllum glabrum* (Keyes) from the Chouteau limestone of Missouri, lacks the long major septa and very conical tabulae. The two specimens at hand may even be juveniles.

Family LITHOSTROTIONTIDAE

Genus LITHOSTROTIONELLA Yabe and Hayasaka, 1915

1915. *Lithostrotionella* YABE AND HAYASAKA, Journ. Geol. Soc. Tokyo, vol. 22, p. 94.

Lithostrotion of authors [especially in North American literature].

LITHOSTROTIONELLA CONFLUENS Easton, new species

Plate 1, figure 12; plate 2, figures 8, 9

Externals.—Coralla irregularly spherical, the largest specimen at hand measuring over 14 cm. in greatest diameter, but still incomplete. Corallites in a small corallum with well-preserved externals vary from polygonal cross sections in the center of the corallum to circular cross section where several individuals extend above the general surface level. Epitheca coarsely wrinkled. Corallites contorted where they are in border positions in the colony.

Corallites nearly cylindrical except near the calyces, where they flare broadly. Calyces shallow peripherally and bounded by a thin theca separating adjacent polygonal individuals. Axial portions of corallites moderately deep, with a thin bladelike columellar plate extending above the deepest part of the calical floor but not reaching the level of the peripheral floor. Calyces about 1 cm. in diameter on the average. Septal traces on the calyx floor become increasingly prominent axially.

Transverse sections.—A mature calyx of the holotype (diameters 9 mm. by 15 mm.) has 24 major septa alternating with minor septa. Within the tabularium the major septa are slightly thickened and tend to fuse with the axial complex. One major septum is longer than the others and may fuse with another major opposite it to form a continuous median septum, but in any case the long septum is much thickened by stereoplasm to form the narrowly elliptical axial plate.

The dissepimentarium is broad, occupying one-fourth to one-third of the diameter of the calyx. Its outer portion is typically lonsdaleoid, some of the larger vesicles occupying the space between three or four septa. The inner portion of the dissepimentarium consists of nearly concentric dissepiments spaced somewhat more closely than in the outer region. The major portion of the dissepimentarium is thickened with stereoplasm to approach the character of an inner wall. Where lonsdaleoid dissepiments are absent and the rows can be counted, there are from 8 to 12 rows of dissepiments, with an average of about 10. Although as many as 24 major septa may be present, the calyces most often have about 20 major septa. Major and minor septa are equally thin and somewhat sinuous in the dissepimentarium, neither order touching the epitheca except locally. Only the very tips of the minor septa extend into the tabularium from the dissepimentarium.

Tabellae occur in the axial region. Some loculi lack tabellae and others may have up to eight rows. Some tabellae are straight, some concave axially, and others convex axially, but they are roughly concentric.

If tabulae are present, they cannot be distinguished from the dissepiments and tabellae.

Longitudinal section.—A section of the holotype shows a band of axially convex elongate dissepiments sloping proximally at an angle of about 45° near the epitheca but becoming smaller and vertical axially. In a transverse line there are usually about seven rows of dissepiments. Each corallite has its own epitheca, separated from the adjacent epitheca by a dark line.

In the tabularium is the solid area of the axial plate, from which large tabellae slope proximally at a very low angle and then slope steeply at their outer edges. Some tabellae even have a sag in them before turning down abruptly and another sag where their extreme outer edges curved distally a short distance. The outer sag corresponds in position to the very rare, short, distally concave tabulae.

Comparison.—This species is characterized externally by the broadly flaring distal portions of the calyces and the depressed calyx floor in the axial region. Internally it is characterized by the similar major and minor septa in the dissepimentarium, the irregular pattern of the lonsdaleoid dissepiments, the slightly thickened axial portions of the major septa, the tendency of major septa to touch the column, and the stereoplasmic thickening of structures to resemble an inner wall.

Lithostrotionella confluens differs from *L. castelnaui* Hayasaka, which it resembles somewhat, in having stronger minor septa, longer major septa, a thicker columellar plate, and less steeply dipping tabellae than has the latter species.

Occurrence.—Unit 3, 4 specimens in collection, numerous left on outcrop; unit 1, 1 specimen; undifferentiated, 9 specimens.

Material.—Holotype, U.S.N.M. 127939; paratype, U.S.N.M. 127938; topotypes, U.S.N.M. 127960; U.S.C. 4071 and 4072.

Remarks.—It is possible that the axial structures referred to as tabellae here are really tabulae. A few more or less horizontal elements with a proximal sag were observed locally between the dissepiments and the tabellae; the writer refers to the inner elements as tabellae and the rare periaxial series as tabulae.

Family uncertain

Genus CYSTELASMA Miller, 1891

Stumm (1948, pp. 68, 69) has recently reviewed the genus and has redescribed several species.

CYSTELASMA INVAGINATUM Easton, new species

Plate 1, figures 11, 20, 24

Externals.—Small, curved, ceratoid to cylindrical, and contorted, from 1 cm. to 3 cm. long, and with the calyx from 6 mm. to 8 mm. in diameter. Theca thin. Interseptal ridges faint to absent. Irregularly spaced rugae occur. Prominent constrictions indicate rejuvenescence, and a coral may be contorted (geniculate) at one or more of the constrictions. Apical angle about 35° when coral is regularly flared. Two

of the high geniculate paratypes have strong spinelike processes indicating the side of attachment along recumbent individuals.

Calyces.—Calyces opening at a right angle to the axis, extremely deep, usually without tabulae on their floors. Septa thin and marginally retracted distally; slightly swollen proximally and at the bottom of the calyx. Secondary septa not observed.

In a paratype, U.S.N.M. 127942 (diameters 4.5 mm. by 6 mm.), the calyx of which illustrates the early ephebic stage, there are 19 septa about half of which nearly touch axially. The counter septum is longest and most prominent, being slightly thicker and persistently longer than the other septa in the distal portions of the calyx. It occupies the counter fossula formed by somewhat wider spacing between it and each adjacent septum. The latter two septa curve away from the counter septum proximally. The cardinal septum is somewhat swollen but is almost the shortest septum. It occupies the faintly differentiated cardinal fossula formed by the curving away laterally of each adjacent septum. The short right alar septum occupies a true fossula of weak expression, whereas the short left alar septum is fused to the adjacent strong septum on its cardinal side and is bordered on the counter side by an alar pseudofossula. Altogether, seven of the septa are long, including the counter septum, one septum on the cardinal side of each alar septum, and the second and third septa on both sides of the counter septum. The distal edge of a tabula lies deep in the counter fossula but cannot be seen elsewhere.

In the holotype (diameters 7 mm. by 8 mm.), whose calyx illustrates the very late ephebic or the gerontic stage, there are 21 septa. Four tabulae are present in the calyx, inclined cardinally at about 45° to the axis, except where they are abruptly depressed into the nearly vertically walled cardinal fossula. The short cardinal septum crosses the cardinal fossula. Most of the other septa extend out onto the distal surfaces of the tabulae about one-half the radius but retreat in a short distance to their normal length of less than one-quarter the radius.

Internal structure.—Where the theca of the holotype is broken away, internal structure can be seen. Tabulae are complete and are inclined steeply. They are quite irregularly spaced, from less than 1 mm. to more than 2 mm. apart. Notable features are their crowding at geniculations and their approximately parallel arrangement. This latter feature transgresses other structure so that the tabulae are steeply inclined proximally and may be nearly vertical or at a low

angle in other portions of the coral, depending upon the directions in which the coral chanced to grow.

In the proximal portion of the holotype is a stage similar to that in the figured calyx of the paratype. Eighteen septa are present, arranged as in the paratype. Fossulae are discernible in the cardinal, counter, and right alar positions.

The apex of the paratype (diameter about 1.5 mm.) has six septa and a tabula.

Comparison.—*Cystelasma invaginatum* resembles *C. septatum* Greene, 1901, more closely than it resembles other American species, particularly in the prominence of the metasepta (rather than having majors other than protosepta represented by ridges on the interior of the calyx). *C. invaginatum* differs from *C. septatum* and from all other species of the genus, however, in having the tabulae inclined steeply proximally, instead of having them horizontal.

Occurrence.—Unit 3, 1 specimen, possibly 2 others; unit 1, 1 specimen; undifferentiated, 15 specimens.

Material.—Holotype, U.S.N.M. 127941; paratype, U.S.N.M. 127942; topotypes, U.S.N.M. 127958, U.S.C. 4065, 4270.

Remarks.—*Cystelasma invaginatum* may be confused with *Amplexus* or with amplexoid phases of other genera, notably *Caninia.* Convergence of this nature has led authors to make *Amplexus* the catchall that it has been. *C. invaginatum* is readily distinguished from *Amplexus* by the steeply sloping tabulae and by the swollen septa.

C. invaginatum possesses morphologic features of a low order of specialization, yet related to the other species of the genus. It is apparent from the geniculate form that *C. invaginatum* could change its direction of growth one or more times. Presumably the impelling cause would be either an effort to achieve better position with regard to current and food while standing erect on the sea floor, or to right itself after having become recumbent through some accident. There is no indication on the apical portions of the corals examined that the species was attached to any solid foreign object; hence, it must be assumed that *C. invaginatum* grew from the sea floor directly. This assumption tends to be substantiated by the fact that the apical portions of some specimens show a cylindrical phase in early maturity, followed by rapid flaring of the individuals; these phenomena can be interpreted as an initial effort to increase the speed of elongation in order to get above the ocean floor, followed by normal flaring of the skeleton when favorable conditions of growth were attained. Identical changes in shape are known for other rugose corals, although the

writer is not aware of previous attempts to explain the changes. In *C. invaginatum* the animal did not increase in diameter after maturity, but did continue to build up its skeleton to form the cylindrical phase of late maturity. It is quite possible that the organism fell over because its considerable length and weight proved to be too much of a strain for its feeble method of fixation to the substratum. In this case the recumbent animal would grow in a new direction in order to get above the zone of moving sediment and into a more favorable environment. The foregoing explanation is difficult of absolute proof, but at least utilizes ecologic considerations in explaining the morphology of one geniculate coral species. Better evidence than the foregoing has been marshaled (Easton, 1945, p. 628) for *Amplexus adnatus,* in which spines of attachment bear a definite relationship to geniculations.

In terms of evolutionary development, *C. invaginatum* is more primitive than *C. lanesvillense, C. septatum,* and *C. tabulatum* (all from the Salem limestone of Meramec age) in one or more of the following features. Ridgelike metasepta in most *Cystelasma* must be from an earlier septate condition, such as exists in *C. invaginatum* and to a lesser degree in *C. septatum.* Dissepiments in many strains of corals progressively occur higher and higher in corallites as evolution progresses, hence *C. invaginatum* with dissepiments in early stages is more primitive in this character than are species like *C. lanesvillensis* and *C. septatum.* The thin theca with faint septal grooves sometimes present, is more primitive than the very thick, nongrooved thecae of the higher species. These evolutionary features indicate that *C. invaginatum* occurs in strata older than the Salem limestone.

Order TABULATA

Family FAVOSITIDAE

Genus **PLEURODICTYUM** Goldfuss, 1829

1829. *Pleurodictyum* Goldfuss, Petrefacta Germaniae, vol. 1, p. 113.

Michelinia of authors.

Remarks.—Paleontologists are not even in approximate agreement as to the taxonomic status of *Pleurodictyum.* Several schools of thought exist with diverse interpretations of *Pleurodictyum, Michelinia,* and related genera or subgenera. As previously utilized (Easton, 1943, p. 136; 1944, p. 55), the writer retains *Pleurodictyum* for *Michelinia* of authors.

PLEURODICTYUM SUBRAMOSUM Easton, new species

Plate 1, figures 15, 16

Description.—*Pleurodictyum* with nearly ramose cylindrical corallites arising from a massive region of polygonal or subcylindrical corallites. Epitheca with numerous fine encircling wrinkles.

Mature calyces 7 mm. or 8 mm. in diameter and up to 5 mm. deep. More or less complete tabulae irregularly spaced but usually notably depressed at one place. Calyx walls may be free and lined with obscure septal traces or spines, or may be covered with vesicular tabulae.

Where two corallites are in contact, irregularly spaced, large, generally oval mural pores are present. When mural pores are roughly in line, five occur in 3 mm.

Comparison.—*Pleurodictyum subramosum* differs from *P. expansum* (White) in changing from massive to ramose habit, in having septal spines, and in having funnel-like calycal floors. Its growth habit is sufficient to distinguish it from other species of *Pleurodictyum* known to the writer.

Occurrence.—Undifferentiated, 4 specimens.

Material.—Holotype, U.S.N.M. 127940; paratypes, U.S.N.M. 127943.

Remarks.—Under recent tendencies in the systematics of the tabulate corals, the growth habit of this species would be of sufficient importance for the erection of a new genus. In view of the fact that the best specimen is incomplete proximally, the writer prefers to propose the species as a readily recognizable *Pleurodictyum*.

Family SYRINGOPORIDAE

Genus SYRINGOPORA Goldfuss, 1826

1826. *Syringopora* Goldfuss, Petrefacta Germaniae, vol. 1, p. 76.

Syringopora of authors.

Remarks.—Although several syringoporoid genera have been proposed, the writer is unable to assign specimens of the material under study to any of the genera as described. Under the circumstances, it is better to use the old genus *Syringopora* as generally understood and avoid possible further systematic complications. The material at hand approaches *Kueichowpora* but also has affinities with *Tetrapora*.

Remarks.—Among the detritus from acidization of the limestone is a large amount of fragmentary coralline material of doubtful affinities. Much of it is probably referable to *Syringopora*, but some may be *Cladochonus*. The fragments in question are recumbent series of

budded tubes, with the individual corallites becoming erect. Other examples show a roughly syringoporoid alignment of corallites with irregularly placed connecting processes. Some corallites are hollow and others contain tabular structures, but the hollow ones may be the result of differential silicification which did not allow preservation of the tabulae. In any case, examples occur frequently which show traces of septal spines. It is probable that these fragments represent the ontogenetic change from recumbent to erect habit of growth in *Syringopora*.

SYRINGOPORA TUBIFERA Easton, new species

Plate 2, figure 10; text figure 3

Description.—Corallites subparallel, 1.5 mm. in diameter, and about 4 corallites occurring in 10 mm. Connecting processes prominent, in four rows. The processes in one plane are more consistently present than are those in the other plane; the former are 3 mm. to 4 mm. apart and are slightly arched; the latter may be locally as abundant as the former and may be located at the level of the former. Epitheca thin with faint encircling striae. In some instances open ends of corallites are lined internally with rows of very faint septal spines, there being about 30-34 in each corallite.

In transverse section the corallites are circular or nearly so. Small septal spines line the epitheca. Tabulae appear as concentric rings or ovals, varying in number from 2 to 4.

In longitudinal section the tabulae are sharply curved proximally and fuse at their inner ends to form a slender open tube located axially and occupying about one-fourth to one-fifth of the diameter. Tabulae are about 0.5 mm. apart at their proximal ends.

Occurrence.—Unit 1, 2 specimens; unit 2, 1 specimen; undifferentiated, 3 specimens.

Material.—Holotype, U.S.N.M. 127954; paratypes, U.S.N.M. 127955a, b; topotypes, U.S.C. 4073, 2 specimens; U.S.C. 4074, 1 specimen; fragmental topotypes, U.S.N.M. 127955.

Comparison.—This species differs from *Syringopora harveyi* White in having mural processes in four rows, much shorter septa (really septal spines), fewer and longer tabulae, and a nontabulate central tube.

SYRINGOPORA, new species A

Externals.—This species is *principally* characterized by its slender and closely packed corallites. The corallites are about 1.0 mm. in di-

ameter and about six subparallel rows occur in 10 mm. Details of connecting processes and of external structure were not observed.

Occurrence.—Unit 3, 4 specimens; unit 1, 1 specimen.

Material.—U.S.C. 4075, 4 specimens; 4076, 1 specimen.

SYRINGOPORA, new species B

Externals.—A very closely constructed *Syringopora* observed in the field was not collectable. Its corallites are about 4 mm. in diameter.

Occurrence.—Unit 1, fragmentary specimen.

Fig. 3.—Transverse section of several corallites in a colony of *Syringopora tubifera* Easton, ×4, holotype, U.S.N.M. 127954.

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BRACHIOPODA AND PELECYPODA

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(Plates 3-7)

INTRODUCTION

All the brachiopods described herein, except one species as noted below, came from the small knob of Represo limestone located 1½ miles west-northwest of Bisani, in northwestern Sonora. Nearly all the specimens from this knob come from the middle cherty limestone of 14-feet thickness (Cooper and Arellano, 1946).

The collection of brachiopods is small and most of the specimens are fragmentary. This unfortunate condition was brought about by the necessity of dissolving them from limestone. These silicified specimens are generally very fragile and the rocks much fractured. Many of the specimens fell apart and could not be saved. Others had to be patched together. In spite of all these difficulties 21 genera and 25 species are described. A few of the specimens, although fragmentary, are exceptionally good, such as the *Reticularia cooperensis* which are the first good interiors to be figured for this genus.

The age of the Represo brachiopods is clearly Early Mississippian (Kinderhookian) but some species suggest an early Osagian age or Medial Mississippian age. *Cyrtospirifer latior* (Swallow), *Hustedia circularis* (Miller), and *Reticularia cooperensis* (Swallow) are characteristic Chouteau species, whereas *Crurithyris laevicula* (Rowley), *Cyrtina burlingtonensis* (Rowley), *Leptaena,* and *Dielasmoides,* although present in the lower Mississippian, range into the Osagian (Burlington).

Absence of productids is noteworthy but this may be due to incomplete or selective silicification. Productids are not abundant in the Chouteau fauna and their absence in this one may be due to a facies condition. Actually the outcrop from which these fossils were taken is very small and the specimens collected may not represent a good sample of the fauna.

Specimens of one species of brachiopod were taken from the Venada limestone in the small hill 1½ miles west of Bisani. These brachiopods belong to the genus *Perditocardinia* now known only from

the Warsaw to Ste. Genevieve divisions of the Middle Mississippian and thus younger than the Represo fauna.

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M. H. Nitecki, Curator, Walker Museum, University of Chicago, kindly lent some of Stuart Weller's types, which were useful in settling certain systematic problems. My thanks also go to the Bursary Aid Program, Yale University, and M. F. Williams, for aid in making the plates, and to Mrs. M. B. Beach for typing the manuscript.

BRACHIOPODA

SYSTEMATICS

Suborder DALMANELLOIDEA Moore 1952

Family RHIPIDOMELLIDAE Schuchert 1913

Genus RHIPIDOMELLA Oehlert, 1890

RHIPIDOMELLA cf. R. MISSOURIENSIS (Swallow), 1860

Plate 3,A, figures 1-3

1860. *Orthis missouriensis* Swallow, Trans. St. Louis Acad. Sci., vol. 1, pp. 639-640.

1914. *Rhipidomella missouriensis* Weller, Geol. Surv. Illinois, Monogr. 1, pp. 148-149, pl. 20, figs. 1-8.

Weller's subdivision of the Mississippian *Rhipidomella* is based chiefly on internal features, but to some extent on the exteriors. Three of the species he recognized, *R. missouriensis* (Swallow), *R. oweni* Hall and Clarke, and *R. burlingtonensis* (Hall), resemble each other very closely externally and require confirmation of interior details for accurate specific designation. The Represo collection contains only a single complete specimen and fragments of two others, none of which reveals internal characteristics. On the basis of size and shape the species appears closest to *R. missouriensis.*

Figured specimen.—U.S.N.M. 127910.

Genus PERDITOCARDINIA Schuchert and Cooper, 1931

PERDITOCARDINIA cf. P. DUBIA (Hall), 1857

Plate 3,B, figures 4-7

1857b. *Orthis dubia* Hall, Trans. Albany Inst., vol. 4, p. 12.

1914. *Rhipidomella dubia* Weller, Geol. Surv. Illinois, Monogr. 1, pp. 160-161, pl. 83, figs. 9-10.

1932. *Rhipidomella* (*Perditocardinia*) *dubia*, SCHUCHERT AND COOPER, Mem. Peabody Mus. Nat. Hist., vol. 4, pt. 1, p. 135, pl. 19, figs. 12, 16-17, 20-22.

Examples of shells closely resembling Hall's species are present in this collection and come from the Venada limestone in the small hill 1½ miles west of Bisani. The beds containing *P. dubia* are younger than the Chouteau because Hall's species ranges from the Warsaw to the Ste. Genevieve horizons, so far as is presently known, and both of these overlie the Chouteau equivalents in the Mississippi Valley sections.

Figured specimens.—U.S.N.M. 127911a, b.

Family SCHIZOPHORIIDAE Schuchert and LeVene, 1929

Genus SCHIZOPHORIA King, 1850

SCHIZOPHORIA SULCATA Sanders, new species

Plate 3,C, figures 8-22

Exterior.—Shell transverse, a little wider than long, widest at mid-length; margins rounded; hinge line straight; cardinal margins obtuse to rounded; lateral profile biconvex, with dorsal valve having greater convexity; anterior commissure rectimarginate; front margin slightly emarginate; sulcus faint on both valves, more prominent on dorsal valve. Ventral interarea gently apsacline, gently curved; beak faintly curved; umbone small, pointed; dorsal interarea orthocline, gently curved; beak curved, umbone pointed. Surface multicostellate, some costellae hollow with holes leading to exterior. Shell finely punctate.

Ventral interior.—Delthyrial cavity deep; teeth stout, clublike, with posterior surface parallel to interarea and with small accessory sockets; crural fossettes oblique; dental plates located directly under teeth, but forming walls of delthyrial cavity and edge of delthyrium, continued forward as ridges bounding muscle field; muscle field bilobate, divided by narrow ridge whose base widens anteriorly to form raised, inverted V-shaped prominence; adductors small, borne on median ridge; diductor scars elongate, divergent, each pair separated by a faint low ridge. A large trunk of the pallial sinuses originates at the forward edge of the diductor impression.

Dorsal interior.—Notothyrial cavity wide, deep, bounded by divergent, slightly curved brachiophore supporting plates, which are continued anterolaterally as faint ridges bounding muscle field; brachiophores stout, slightly recurved over dental sockets, not separable from supporting plates; fulcral plates curved, attached to inner overhanging edge of palintrope; very faint denticle along free inner edge

of palintrope, just lateral of sockets. Cardinal process prominent; shaft a narrow septumlike ridge; myophore bilobate, with muscle markings on posterolateral sides; accessory cardinal processes present on floor of notothyrial cavity between shaft and brachiophore supporting plates. Muscle area large, divided by faint, low median ridge. Pallial sinuses prominent, four originating near median line, two on each side of the median ridge and two more at anterior extremities of ridges separating adductors.

Types.—Holotype, U.S.N.M. 127915a; figured paratypes, U.S.N.M. 127915b-h; unfigured paratype, U.S.N.M. 127915.

Distinguishing characters.—The biconvex lateral profile of this species is very characteristic and somewhat unusual for *Schizophoria.* The species is further distinguished externally by the sulcus on each valve, especially by the prominent sulcus on the dorsal valve, a feature that inspired its name.

This species resembles *S. sedaliensis* Weller, 1914, but that species lacks a sulcus on the dorsal valve. *S. chouteauensis* Weller, 1914, is also biconvex, but seems to have a deeper ventral valve and lacks the dorsal sulcus. Unfortunately the interior details of Weller's species are not well known, so other possible differences that may exist between *S. sulcata* and the two species externally resembling it cannot be determined.

Remarks.—An interesting example of repair of a shell break made during the lifetime of the animal is shown near the anterior margin of the specimen figured on plate 3C, figure 17 (U.S.N.M. 127915e).

Suborder STROPHOMENOIDEA Maillieux 1932

Family LEPTAENIDAE Cooper, 1956

Genus LEPTAENA Dalman, 1828

Leptaena as here described follows the long usage expressed in Weller (1914) and elsewhere. The writer has made no attempt to trace the original usage and genotype to determine if his usage corresponds exactly to the original.

McCoy (1844, pp. 116-117) proposed *Leptagonia* based on *Producta analoga* Phillips, 1836, but McCoy's name has not been used because *P. analoga* Phillips has hitherto been regarded as a *Leptaena.* The interior of Phillips's species is unknown, so far as the writer is aware, but when known might provide a basis for generic distinction. *Leptaenella* Sarycheva and Sokolskaja, 1952, also based on *Producta analoga* Phillips, is a synonym of *Leptagonia* McCoy. Furthermore,

the name *Leptaenella* is preoccupied by Fredericks (1917), for a genus based on *Leptaena rhomboidalis ventricosa* Hall, 1857a, *Leptaenella* Sarycheva and Sokolskaja is thus a homonym as well as a synonym and must be discarded.

LEPTAENA COOPERI Sanders, new species

Plate 4,A, figures 1-5

Most Mississippian leptaenas are referred to *L. analoga* (Phillips), 1836, a Lower Carboniferous species from England, but the internal morphology of Phillips's species is still undescribed. Rather than assign the present specimens to a widely used species whose interior is poorly known and where interiors are unavailable for comparison, the author erects a new species for these Mexican shells, based on their internal morphology. This new species appears to differ externally (and the few interior details that can be seen from the illustrations) from the shells Weller (1914) assigned to *L. analoga* (Phillips) and also from *L. convexa* Weller.

Exterior.—Shell transverse, twice as wide as long, widest at hinge line, flattened, planoconvex, with posterior portion of ventral valve gently convex, corresponding part of dorsal valve flat, sharply geniculate anteriorly, the point of geniculation on the dorsal valve being sharply angular in front and becoming more obtuse toward cardinal extremities. Cardinal extremities acute, pointed; front margin semielliptical, slightly emarginate; hinge straight; ventral interarea apsacline, narrow, gently concave; beak slightly curved; delthyrium closed at apex by a broad pseudodeltidium. Dorsal interarea anacline, nearly obsolete; beak only faintly pointed. Surface of both valves multicostellate, with much finer pattern of concentric lirae superposed on costellae; both of these modified by larger, irregular, rounded concentric corrugations.

Ventral interior.—Notothyrial cavity broad, deep, semicircular, forming great sunken pitlike area for muscle attachment, bounded posterolaterally by thickened valve margin supporting teeth, anteriorly by a curved elevated ridge, apex with triangular flattened area; teeth blunt, elongate, clublike, crenulated, with long axis directed laterally, with growth track forming crenulated area from beak along outer edge of delthyrium, bounded posteriorly by small accessory sockets which merge laterally into a small groove along inner edge of cardinal area and apparently extending to cardinal extremity. Muscle areas occupying pitlike notothyrial cavity, with posterior portion smooth, undivided; separated for most of extent by a wide, rounded

ridge which bears elongate adductor impressions, with pointed median ridge located atop this broader rounded ridge. Diductor impressions not shown on shells examined. Remainder of interior of valve papillose, except for large pallial trunks at front of muscle field.

Dorsal interior.—Interarea separated from rest of valve by a faint ridge; notothyrium wide, low, filled by cardinal process; chilidium fused to posterior face of cardinal process, with median groove leading to beak over space between two lobes of cardinal process; bilobed cardinal process with diductor scars on vertical posterior face; dental grooves rounded, widely divergent, crenulated, bounded on both sides by ridgelike outer and inner socket plates, floored by posterior wall of valve; muscle area diamond-shaped, occupying about one-fifth of the area within elliptical visceral region, bounded posterolaterally by stout rounded ridges parallel to ridge made by inner socket plate, merging posteriorly with lobe of cardinal process, anterolaterally by edge of raised muscle platform, divided medianly by a Y-shaped ridge which culminates anteriorly in a pointed, raised knob and divides posteriorly to join bounding ridges which lead to cardinal process at about right angles; posterior adductor field a flattened area just anterior to this junction of ridges, with anterior adductors occupying deep elliptical pits on opposite sides of narrow median ridge just posterior to pointed anterior termination of median ridge; pallial trunks diverge widely from anterior adductor impressions; remainder of visceral area papillose.

Types.—Holotype, U.S.N.M. 127916a; figured paratypes, U.S.N.M. 127916b, c.

Remarks.—Demanet (1934, pl. 5, fig. 7) illustrated the interior of a species from Tournai, Belgium, referred to *Leptaena analoga* (Phillips), which closely resembles *L. cooperi.* These Mexican shells agree in general with the shells illustrated by Demanet, but appear to differ significantly in certain proportions. Large collections might invalidate these distinctions, but comparison of *Leptaena cooperi* with Demanet's *L. analoga* (Phillips) shows the Belgian specimens to be wider, with extended cardinal extremities, and with slightly less abrupt geniculation than in *L. cooperi.* Interiorly, the visceral area of the dorsal valve is slightly more than semielliptical, bisected by the straight hinge line in the Belgian specimens, with the muscle area distinctly raised and the median septum extending about two-thirds of the distance across the visceral area. In *L. cooperi,* on the other hand, the visceral area forms a nearly complete ellipse, slightly indented along the front edge, the muscle area is not so prominently raised, and the median septum extends to just the midpoint of the visceral area.

Family SCHUCHERTELLIDAE Stehli, 1954

Genus SCHUCHERTELLA Girty, 1904

Schuchertella is thought to differ from *Schellwienella* in lacking dental plates. This difference holds true for the specimens of this collection, but G. A. Cooper (personal communication) indicates variability in the development of "dental plates" may invalidate the supposed generic distinction based on this feature alone. The dorsal interiors of the shells here assigned to *Schuchertella* differ considerably from the corresponding parts of shells referred to *Schellwienella,* and might ultimately provide a reliable basis for generic distinction if this information can be obtained from the type species of the two genera concerned.

SCHUCHERTELLA species

Plate 4,B, figures 6-14

Exterior.—Only fragments of the valves near the hinge line are preserved, and they represent an apparently flattened, biconvex schuchertellid bearing rounded, threadlike costellae separated by implantation in the interspaces of smaller costellae which gradually increase in size anteriorly; interarea flat, delthyrium bounded by wide perideltidial areas.

Ventral interior.—Thickened teeth occurring along inner edges of delthyrium, unsupported below; pseudodeltidium closing delthyrium to apex, fused to inner edges of growth track of tooth; muscle marks not strongly impressed into shell.

Dorsal interior.—Cardinalia fused together; cardinal process bilobed, erect, in plane of commissure; base divided, platformlike, overhanging outer surface of dorsal valve at apex, with base of each half fused to stout, rounded ridges, forming the inner socket plates (brachiophores), which taper anterolaterally to rounded bladelike ends; sockets not excavated from shell, formed by upward growth of stout inner socket plate-brachiophore, bounded posteriorly by margin of valve; chilidium fused to base of cardinal process. No muscle marks impressed on shell.

Figured specimens.—U.S.N.M. 127917a-c.

Remarks.—The dorsal interiors of many of the Mississippian strophomenoids are poorly known; consequently, the writer is in a poor position to assess the significance of the variability of these structures or to follow the changes during growth of an individual. Other specimens in the collection show a median ridge on the inner side of

the cardinal process and large muscle areas separated by a faint, low, rounded median ridge. These have also been assigned here, but largely by default, as too few specimens are available to evaluate the significance of these changes.

Genus SCHELLWIENELLA Thomas, 1910

SCHELLWIENELLA UMBONATA Sanders, new species

Plate 4,C, figures 15-21

A large dorsal valve and a smaller fragment of the hinge portion of a ventral valve are presumed to belong together and are made the basis of a new species of *Schellwienella.* Though numerous species of this genus have been described, the internal characters of the dorsal valve are scarcely known. Weller (1914) described several new species from single dorsal valves only, and as that valve seems to be the more useful one for specific determination, a new species is here erected even on the basis of the admittedly somewhat incomplete material. The dorsal valve shown conceivably could belong to *Derbyia* or *Orthotetes.* However, status of our knowledge of the dorsal cardinalia in these genera does not provide confirmatory evidence on this possibility.

Exterior.—Shell transverse, a little less than twice as wide as long, semicircular in plan, widest at or just anterior to hinge line; hinge straight; cardinal extremities blunt, nearly right angles. Ventral valve flattened, interarea plane, apsacline; pseudodeltidium completely closing delthyrium. Dorsal valve convex, rotund, with greatly swollen umbonal region, greatest convexity just posterior to middle, the median profile sloping abruptly posteriorly and more gradually anteriorly; cardinal margins flattened, with slightly concave contour; fold and sulcus lacking; dorsal interarea narrow, plane, anacline. Surface multicostellate, with slight reticulation where threadlike concentric lirae cross narrow costellae. Surface ornament poorly preserved, but costellae of several sizes present, especially posteriorly.

Ventral interior.—Teeth stout, divergent, supported by thin dental plates; muscle area not visible; median ridge faint, low, and rounded.

Dorsal interior.—Notothyrium wide, low, filled completely with erect cardinalia, except for growth track of dental groove along outer margins; chilidium fused to outer side of cardinal process; dental sockets divergent, bounded posterolaterally by interarea, floored by stout fulcral plates which are fused to brachiophores, and inseparable from inner walls of sockets; cardinal process erect, fused to posterior wall of valve and brachiophores, with diductor attachment areas

marked by closely set parallel striations, bounded laterally by stout rounded ridges; interior side of cardinalia nearly smooth except for irregular, offcenter ridge. Adductor field deeply impressed, circular, separated by a broad, low, rounded median ridge, which extends the full length of the muscle area.

Types.—Holotype, U.S.N.M. 127918a; figured paratype, U.S.N.M. 127918b.

Distinguishing characters.—The swollen umbone and flattened, slightly concave cardinal extremities of the dorsal valve are especially characteristic of this species, as compared with others previously described, but it must be admitted that this comparison is made upon this single specimen versus a very small number of specimens of the other species. How the cardinalia compare with other species of the genus, unfortunately, cannot be stated.

Suborder CHONETOIDEA Muir-Wood, 1955

Family CHONETIDAE Hall and Clarke, 1895

Genus PLICOCHONETES Paeckelmann, 1930

PLICOCHONETES GENICULATUS (White), 1862

Plate 3,F, figures 30-32

1862. *Chonetes geniculata* WHITE, Proc. Boston Soc. Nat. Hist., vol. 9, p. 29.
1914. *Chonetes geniculatus* WELLER, Geol. Surv. Illinois, Monogr. 1, pp. 92-93, pl. 8, figs. 35-42.

Discussion.—Paeckelmann (1930, pp. 222-223) proposed *Plicochonetes* as a subgenus of *Chonetes,* based on *Chonetes buchiana* de Koninck, 1844, for Devonian and Carboniferous chonetids with radially plicated shells, which were assigned by de Koninck (1847) to the "plicosae" and a few to the "striatae" and "rugosae." No internal characteristics were cited.

The present shells are referred to Paeckelmann's genus on the basis of external ornamentation. The assignment to *P. geniculatus* likewise is based on external characters. The present shells agree well with Weller's (1914, pp. 92-93) description of White's decidedly concavo-convex species, though the Mexican shells are a little larger than the ones figured by Weller. *G. glenparkensis* (Weller, 1906) is similar but has a wider hinge line and more definite auriculations.

Other specimens in the collection show interior details of the ventral valve and indicate flat, rounded, unsupported, shelflike hinge teeth flattened parallel to the hinge line, and a short median septum.

Certain other specimens in the collection (not illustrated) may

belong to *Chonetes logani* Norwood and Pratten (1855) because of their crenulated ornamentation and slightly wider hinge line.

Type.—Holotype, U.S.N.M. 127914.

Suborder TEREBRATULOIDEA Muir-Wood, 1955

Family DIELASMATIDAE Schuchert and LeVene, 1929

Genus GIRTYELLA Weller, 1911

GIRTYELLA species

Plate 5,C, figures 12, 13

Two fragments of dorsal valves are assigned to *Girtyella* species on the basis of punctate shell structure and the presence of a concave hinge plate supported by a median septum anteriorly. The loops are not preserved. The specimens are too incomplete to attempt species assignment.

Figured specimens.—U.S.N.M. 127923a, b.

GIRTYELLA? species

Plate 5,C, figures 9-11

This small terebratuloid assigned to *Girtyella?* yields no clue as to its interior details. Whether it belongs with the incomplete dorsal valves of *Girtyella* species above is conjectural.

Figured specimen.—U.S.N.M. 127922a.

Genus DIELASMOIDES Weller, 1911

Stehli (1956) has revealed that the dorsal interior of the genotype of *Dielasma* has a sessile cruralium with crura arising from the walls of the cruralium near the inner socket plates, a plate arrangement like that of the species upon which Weller (1911) erected the genus *Dielasmoides*. Stehli (pp. 300-301) therefore regards *Dielasmoides* as a junior synonym of *Dielasma,* as the latter is now known. However, he also indicates (p. 301) that the genotype of *Dielasma* has a cardinal process, a feature which is likewise clearly shown on the etched silicified specimens of *Dielasma* sp. from the Middle Permian of Texas (pl. 40,B, fig. 6). The Mississippian shells in this collection clearly lack a cardinal process. The present writer therefore recognizes *Dielasmoides* Weller, 1911, as a distinct genus from *Dielasma* King, 1859, as restricted by Stehli (1956), on the basis of the absence of a cardinal process in *Dielasmoides.*

DIELASMOIDES species

Plate 5,D, figures 18-20

Two incomplete specimens showing the dorsal interior morphology of *Dielasmoides* occur in this collection. The external configuration cannot be determined from these fragments, so species assignment is not attempted. Weller (1914) lists only one species of *Dielasmoides, D. bisinuata* Weller, in the genus. Even though specific assignment is not made, the shells here discussed probably belong in a different species than *D. bisinuata,* as the Mexican specimens are very much thicker.

Figured specimens.—U.S.N.M. 127925a, b.

DIELASMOIDES?

Plate 5,D, figures 14-17

The generic assignment of the specimen illustrated on plate 5,D, figures 14-17, is in doubt because no internal morphology can be determined. The specimen is assigned with query to *Dielasmoides.*

Figured specimen.—U.S.N.M. 127924.

Genus BEECHERIA Hall and Clarke, 1894

In his study of the genotype species of *Dielasma* King, 1859, (*D. elongatus* Schlotheim, 1816), Stehli (1956, pp. 300-301) showed that the dorsal interior plate structure of this Permian species from Europe closely resembles that of the Mississippian species from the United States which Weller (1911) took as the genotype of *Dielasmoides,* but that the European species contains a cardinal process and does not have the plate structure commonly regarded as characteristic of *"Dielasma"* by Weller (1914) and other authors. Stehli also pointed out that *Beecheria* Hall and Clarke, 1894, which has been suppressed as a synonym for *"Dielasma,"* should be revived for this group of shells widely misnamed *Dielasma.*

Beecheria is characterized by unusual plates on the floor of the dorsal valve that support the crura and the position of the crural bases. Each crural plate and associated plate unites to form a structure that resembles the pointed roof of a house. These plates are attached to the floor of the dorsal valve and are entirely separate from the inner socket-plate–fulcral-plate structure that encloses the teeth.

BEECHERIA species

Plate 5,E, figures 21, 22

An incomplete specimen on the posterior portion of a large species of *Beecheria* occurs in the collection. The complete shape and type of folding cannot be determined in the absence of the anterior part of the specimen. The interior morphology of the dorsal valve, however, is well preserved, and clearly indicates the genus *Beecheria,* as revived by Stehli (1956). The loop is only partially preserved.

Although the specimen is fragmentary, it preserves a hole bored by some predatory organism. The death of this individual could be attributed to the boring organism.

Figured specimen.—U.S.N.M. 127927.

Suborder RHYNCHONELLOIDEA Moore, 1952

Family CAMAROTOECHIIDAE Schuchert and LeVene, 1929

Genus CAMAROTOECHIA Hall and Clarke, 1894

CAMAROTOECHIA species

Plate 5,A, figures 1-3

Exterior.—Shell subtriangular, with lateral margins straight, front margin straight, anterior corners curved; about as wide as long, widest just anterior to midlength; biconvex, with both valves about equally deep and with flattened profile; both valves deepest at midlength; folding reverses as shell matures, with the dorsal valve in young stages bearing a small median sulcus, becoming a low fold in maturity, and the ventral valve having a raised median portion, not sharply set off from the contour of the valve posteriorly, becoming a wide, flattened sulcus near front margin of mature shell. Costae simple, rounded, defined on beaks, becoming larger and deeper anteriorly, each lateral slope bearing about five costae, the sulcus eight, with furrows a bit wider and flatter than the costae on dorsal valve. Beak erect, pointed, slightly curved; delthyrium narrowly triangular, with small discrete deltidial plates not extending across delthyrium.

Ventral interior.—Dental plates divergent, discrete from walls of valve, forming steep-sided delthyrial cavity, joining valve wall along furrow which bounds sulcus laterally, extending one-fifth the distance to front margin. No muscle marks.

Dorsal interior.—Dental sockets following posterorlateral margin of valve, with socket floor plates curving up and inward to form inner walls of sockets; hinge plate attaching to inner socket plates, divided

medially by flat-bottomed, shallow cruralium, supported by a thin median septum, with free edge tapering gradually toward floor of valve and extending about one-third the distance to the front margin; crura slender, joining hinge plate at junction of edge of cruralium and inner side of divided hinge plate; cardinal process lacking. Muscle markings not present on specimen.

Figured specimen.—U.S.N.M. 127919a.

Remarks.—This is a most distinctive shell and can be accurately characterized in spite of the fragmentary condition of the single specimen examined. Its broken condition permitted description of the interior details, which would not have been possible had the only specimen available been complete.

This shell may belong to *Camarotoechia tuta* Miller, but seems much larger than any examples illustrated by Weller (1914, pl. 24, figs. 9-27). Branson (1938, pp. 45-46) regarded *C. tuta* Miller and *C. chouteauensis* Weller (1914) to be the same species, holding Weller's species to be larger forms of Miller's. The *C. tuta* of Branson (1938, pl. 5, figs. 14-18) has unequally deep valves, a feature in common with Weller's *C. chouteauensis,* but which is not shown on Weller's illustrations of *C. tuta.* This shell also approaches some of the specimens of *C. mutata* (Hall) shown in Weller (1914, pl. 24, figs. 53-60). These differ in profile from the other specimens of *C. mutata* (Weller, 1914, pl. 24, figs. 41-48).

DORSISINUS Sanders, new genus

Genotype.—*Centronella louisianensis* Weller, 1914.

Diagnosis.—Smooth-shelled rhynchonellids with deltidium partially closed by incipient deltidial plates, having fold on ventral valve and sulcus on dorsal valve; dorsal interior with cruralium supported by median septum.

Discussion.—*Dorsisinus* is related to *Camarotoechia* Hall and Clarke, *Nudirostra* Cooper and Muir-Wood, 1951 (formerly *Leiorhynchus*), and *Paraphorhynchus* Weller, 1905, by its dorsal interior structure of a cruralium supported by a median septum. *Dorisisnus* differs from all three by its smooth shell and in having a fold on the ventral valve and sulcus on the dorsal valve. The folding of *Dorsisinus* resembles that of *Centronelloidea* Weller, 1914, but *Centronelloidea* is a punctate, loop-bearing terebratulid, whereas *Dorsisinus* is impunctate and contains only crura. The external homeomorphy between these two genera is indeed striking.

The Mexican shells show internal details chiefly, but the material available seems complete enough to confirm the assignment of them to Weller's species. The generic diagnosis is based on study of Weller's original specimens (Walker Museum 6730) and these Mexican interiors. Though the interior details of Weller's specimens cannot be absolutely confirmed, the writer found no punctae in the shells and in several specimens could detect the trace of the dorsal septum through the shell.

Cloud (1942, p. 74) correctly noted that Weller's species is not a terebratulid. Cloud regarded it as an immature rhynchonellid, but the present writer is satisfied that it is a reliable basis for a new genus. This conclusion is strengthend by observations made on some shells in the writer's Tennessee collections.

DORSISINUS LOUISIANENSIS (Weller), 1914

Plate 5,B, figures 4-8

1914. *Centronella louisianensis* WELLER, Geol. Surv. Illinois, Monogr. 1, pp. 241-242, pl. 30, figs. 26-29.

Exterior.—Shells smooth, with oval outline; valves nearly equally biconvex, with ventral valve having slightly greater convexity. Ventral valve with long, slightly curved, pointed beak; delthyrium triangular, partially closed by incipient deltidial plates; umbone bearing well-defined median elevation, becoming broader and less distinct anteriorly. Dorsal valve circular in plan; folding absent in posterior portion, but with wide, shallow, V-shaped sulcus beginning about one-third of the distance to the front margin and becoming wider anteriorly; anterior commissure gently sulcate.

Ventral interior.—Teeth supported by dental plates which are discrete from posterolateral valve wall. Muscle markings not impressed into shell.

Dorsal interior.—Beak pointed, slightly curved; dental grooves follow posterolateral valve wall, with floor of groove curving around to form inner socket plate; hinge plate divided, with outer flat portions attached to inner socket plate, inner edges forming small cruralium, which is supported by prominent median septum. Septum continues forward of cruralium halfway to the front margin. Crura long, slender, arising from inner edges of flat portions of hinge plate, supported below by a thin, vertical plate formed by forward extension of the walls of the cruralium. Muscle attachment areas not impressed into shell.

Types.—Figured hypotypes, U.S.N.M. 127926a-e.

Suborder Spiriferoidea Allen, 1940

Family SPIRIFERIDAE King, 1846

Genus CYRTOSPIRIFER Nalivkin, 1930

Though the spiriferoid species here considered has always been referred to the genus *Spirifer,* discovery of the full morphology of the shell requires that it be assigned elsewhere. Nalivkin's *Cyrtospirifer* appears to be the best resting place for these shells, though it must be admitted that his generic diagnosis is incomplete. Nalivkin emphasized the presence of a transverse delthyrial plate in the apex of the ventral valve as a prominent feature of *Cyrtospirifer* and fully ignored the dorsal interior. On the basis of external ornamentation and the transverse delthyrial plate the present writer assigns these shells to *Cyrtospirifer,* but with full realization of the insecurity of this assignment because of the lack of important interior details of *Cyrtospirifer.* If these Mexican shells are *Cyrtospirifers,* then this is the first record of that genus from undoubted Mississippian rocks. The possession of a transverse delthyrial plate alone scarcely seems a reliable generic character among spiriferids, but the validity of this structure and its distribution among spiriferids awaits further detailed study of this large group of brachiopods.

CYRTOSPIRIFER? LATIOR (Swallow), 1863

Plate 5,G, figures 27-37

1863. *Spirifer latior* Swallow, Trans. St. Louis Acad. Sci., vol. 2, p. 86.
1914. *Spirifer latior* Weller, Geol. Surv. Illinois, Monogr 1, pp. 316-317, pl. 38, figs. 9-13.

Exterior.—Shell spiriferoid, rotund, transverse, about half again as wide as long, widest at hinge; outline semicircular to triangular, with front margin slightly emarginate, cardinal extremities pointed, acute. Valves subequally biconvex, with ventral valve having slightly greater convexity; umbones prominent on both valves. Lateral slopes ornamented by 18 to 20 small, generally simple costae and furrows similar in size, narrowly rounded with most originating at the beak and continuing to front margin, becoming gradually smaller toward cardinal extremities, with a few costae near the fold and sulcus bifurcating on the umbone. Other fine surface markings, if present, not preserved on these specimens. Sulcus on ventral valve costate, narrow, V-shaped, and sharply defined at beak, widening gradually anteriorly; fold on dorsal valve only slightly elevated above the contour of valve; anterior commissure gently uniplicate.

Ventral interarea apsacline, curving gently posteriorly; beak incurved, overhanging; interarea sharply defined from lateral slopes; hinge line nearly fully denticulate, except for small distance on each side of delthyrium, with irregular traces of hinge teeth covering interarea except for small triangular areas on each side of the delthyrium; deltidial grooves prominent. Median costa of sulcus extending from beak to front margin, with other costae in sulcus branching from bounding costa.

Dorsal beak incurved slightly over wide notothryium; interarea orthocline, gently curved, low, sharply defined from lateral slopes; costae of fold originating by bifurcation from a single source on the umbone; fold bounded by furrows which are slightly larger than other furrows on lateral slopes.

Ventral interior.—Hinge teeth thick, supported by prominent, divergent dental plates, joining valve floor well outside borders of sulcus, with transverse delthyrial plate joining dental plates in umbonal region, extending one-fourth to one-third the distance from the beak to hinge line; muscle areas well impressed, forming oval-shaped field extending nearly halfway to the front margin, outlined by forward continuation of dental plates; adductors attaching to low, rounded thickened areas with V-shaped anterior outline between dental plates (pl. 5,G, fig. 32); diductor field enclosing adductors, divided for most of its length by faint, low, rounded median ridge.

Dorsal interior.—Dental grooves bordering notothyrium, widening gradually anteriorly; with interarea forming posterolateral boundary; floor fused to inner side of palintrope; inner socket plates vertical, increasing in thickness and height anteriorly to form prominent triangular terminations. Cardinal process spiriferoid, supported by a pillarlike thickening extending to floor of valve and also supporting posterior portion of inner socket plates; crural bases attaching to lower distal edges of thickened inner socket plates; muscle areas not deeply impressed, divided by a low, rounded median ridge which extends about halfway to the front margin along the floor of the valve.

Types.—Figured hypotypes, U.S.N.M. 127921a-f.

Remarks.—As noted by Weller (1914, p. 317), Swallow's original specimen was not illustrated and has been lost. Weller regarded the specimen in the Greger collection, labeled by Swallow, as an accurate representative of this species and based his description on Greger's specimen. The present usage follows Weller's concept of *S. latior*, which was based only on external characters. The collection provides details on certain internal characteristics. Weller emphasized the

rotund form, lack of change of convexity of the ventral valve near the lateral extremities, and lack of elevation of the fold above the contour of the dorsal valve of the distinguishing features of this species and the Mexican shells assigned here agree in all respects.

Genus TYLOTHYRIS North, 1920

TYLOTHYRIS? species

Plate 7,A, figures 1-3

Exterior.—Dorsal valve transverse, widest at hinge, with slightly mucronate cardinal extremities; interarea nearly rectangular, with inner half near cardinal extremities denticulate; each lateral slope ornamented with 8 to 10 simple, rounded costae and similar intervening furrows, fold defined from beak, becoming wider and higher anteriorly, bearing faint median furrow; anterior half of valve bearing well-developed concentric imbricate lamellae, which are lacking on posterior half of valve, other fine surface ornament lacking or not preserved. Shell impunctate.

Interior.—Notothyrium wide, with interarea forming outer edge of narrow dental grooves; inner socket plate thickening and rising above plane of palintrope anteriorly, forming a clublike process which is rounded below and pointed above; floor of sockets formed by a plate attaching to inner surface of palintrope, line of junction of this plate with palintrope forming boundary between denticulate and nondenticulate portions of hinge line; cardinal process spiriferoid, prominent, rising above plane of palintrope, supported only by coalescence of base with crural bases and inner socket plate; crural bases rounded, diverging from base of cardinal process, joined to lower, inner edge of inner socket plate by crural connecting plates.[6]

Muscle field deeply impressed, slightly wider than sulcus, extending about halfway to the front margin, divided by low, rounded median ridge, extending one-third of the way to front margin, each half subdivided by a rounded ridge which coincides with border of fold.

Figured specimen.—U.S.N.M. 127932.

Remarks.—This single distinctive dorsal valve of a spiriferoid shell in this collection warrants special notice because of the cardinalia. These features indicate the shell is similar to *Tylothyris,* but probably belongs to an unnamed genus which the writer discovered among specimens from the Belgian Lower Carboniferous in the collections of the British Museum (Natural History) in 1953.

[6] Name here used for plates which extend from crural bases to inner socket plates. Crural plates extend from crural bases to floor of valve.

Genus RETICULARIA McCoy, 1844

A diversity of internal structures is concealed beneath a nearly uniform external shape and ornament in reticulariid brachiopods. T. N. George (1932) and Minato (1953) have discussed these shells and have based genera on internal plate arrangement and types of spines. On the basis of their dorsal interiors, the Mexican shells belong to *Reticularia,* as that genus was diagnosed by George (1932). These silicified specimens reveal for the first time the internal morphology of this genus in great detail.

RETICULARIA COOPERENSIS (Swallow), 1860

Plate 6,D, figures 21-30

1860. *Spirifer cooperensis* Swallow, Trans. St. Louis Acad. Sci., vol. 1, p. 463.
1914. *Reticularia cooperensis* Weller, Geol. Surv. Illinois, Monogr. 1, pp. 428-429, pl. 75, figs. 21-33.

The following observations are made on the basis of disjoined individual valves which preserve the hinge structures very well, but which are not complete enough to show the entire external configuration of the shell.

Exterior.—Shell slightly wider than long, widest at midlength, lateral margins circular, cardinal extremities broadly rounded; valves biconvex, with ventral valve having the greater convexity, greatest convexity at midlength; anterior commissure rectimarginate to faintly uniplicate; surface noncostate, but ornamented by narrow concentric, imbricate bands of double-barreled spine bases; shell nonpunctate; internal surface of valves faintly radially striated.

Ventral valve with prominent umbone; interarea small, triangular, faintly striated vertically (trace of fine hinge teeth?), differentiated from lateral slopes by faint angular change of contour, apsacline, curving faintly posteriorly to incurved, overhanging beak; sulcus defined on umbone, narrowly rounded, becoming broadly rounded and ill-defined anteriorly. Dorsal valve with nearly uniform convexity, with fold absent or only faintly raised above contour of valve; interarea narrow, orthocline, curving very faintly rearward to gently curved beak; edge of notothyrium bounded by low ridge along free edge of palintrope.

Ventral interior.—Delthyrium broadly triangular, bounded by stout hinge teeth; dental plates divergent, extending along floor of valve about one-fourth the distance to front margin, continued a little farther anteriorly as faint ridges flanking the muscle area; median

ridge low, pointed, extending from beak about halfway to front margin; muscle field not deeply impressed.

Dorsal interior.—Dental grooves widening anterolaterally, floored by a plate which is parallel to the palintrope, joining rear wall of valve just below plane of the palintrope; inner socket plate vertical, becoming thicker anterolaterally, termination club-shaped; crural connecting plates thin, vertical, fused to inner socket plates, supported at rear of valve by a flangelike plate tapering rapidly along the floor of the valve and continuing halfway to the front margin as a thin, low, rounded median ridge; cardinal process spiriferoid, not well differentiated, occupying rear of shell where interarea, dental grooves, and inner socket plates coalesce; overhanging slightly, supported at sides by inner socket plate and crural connecting plates; muscle field not impressed on shell.

Types.—Figured hypotypes, U.S.N.M. 127931a-d.

Remarks.—The present shells agree externally with those assigned to *R. cooperensis* by Weller (1914), but he was unable to illustrate Swallow's holotype which may be lost. Weller's mention of a median septum in the ventral valve and in the dorsal valve of *R. cooperensis* is based on specimens not illustrated, so the writer cannot be certain if a true median septum or only a median ridge is present in *R. cooperensis.* With the possible exception of this median septum which rapidly becomes only a slight, raised rib along the floor of the valve (Weller, 1914, p. 429), the dorsal interior described by Weller agrees with the Mexican shells. No difference exists if one is allowed latitude in interpreting the word "septum."

The genus *Torynifer* Hall and Clarke, 1894, revived by Cooper (1942) resembles *Reticularia* externally, but differs from it in possessing a concave hinge plate supported by a distinct median septum in the dorsal valve. On calcareous specimens one can see the trace of the hinge plate and septum as dark T-shaped lines at the rear of the dorsal valve. If the type of *Spirifer cooperensis* Swallow bears this internal hinge plate and septum it must be assigned to *Torynifer* and another name sought for the shells here described which are true *Reticularias.*

Weller (1914, p. 428) considered *Spirifer hirtus* White and Whitfield, 1862, to be a synonym of *S. cooperensis* Swallow, 1860, and illustrated the holotype of *S. hirtus* (Univ. Michigan No. 1367) under *Reticularia cooperensis.* The possibility of differences of internal plate arrangement among external homeomorphs in this group of shells, however, suggests such synonymy should be suspended until full knowledge of internal morphology of both species is revealed.

Genus CRURITHYRIS George, 1931

CRURITHYRIS LEVICULA (Rowley), 1900

Plate 7,B, figures 4-8

1900. *Ambocoelia levicula* ROWLEY, Amer. Geol., vol. 25, p. 262, pl. 5, figs. 12-14.

1914. *Ambocoelia levicula* WELLER, Geol. Surv. Illinois, Monogr. 1, p. 462, pl. 77, figs. 26-29.

Exterior.—Shell transverse, a little wider than long, widest at midlength; hinge straight; cardinal extremities blunt, rounded; sides nearly straight; front semicircular, faintly emarginate; valves biconvex, the ventral valve having greater convexity, dorsal valve flatly convex; ventral interarea apsacline, nearly catacline, gently curved, rounding broadly onto lateral slopes, only faintly outlined; beak incurved, overhanging; umbone swollen; dorsal interarea anacline; beak gently curved, pointed; ventral sulcus narrow, well defined on umbone, widening only slightly anteriorly; profile of valve straight from median line to flattened central portion; dorsal valve also with faint median sulcus; anterior commissure rectimarginate; delthyrium and notothyrium triangular, open, with no covering plates preserved.

Ventral interior.—Teeth thickened, unsupported by dental plates, joined at apex by small transverse delthyrial plate. No other features observable on specimens examined.

Dorsal interior.—Palintrope overhanging, forming outer boundary of dental sockets; sockets floored by fulcral plate parallel to palintrope, but set a little below it, attaching to posterior wall of valve; inner socket plates inclined toward socket; cardinal process large, clublike, attaching to posterior wall of valve; crura diverging from base of cardinal process and projecting into valve following close along the contour of the valve wall, joined to junction of inner socket plate and fulcral plate by thin crural connecting plate, supported by small crural plates which join valve wall near base of cardinal process; jugum or jugal processes lacking; muscle markings only faintly impressed, appearing elongate and oval in outline.

Types.—Figured hypotypes, U.S.N.M. 127933a-b.

Discussion.—The interior of the dorsal valve of Rowley's species was not described by Weller, so the present assignment rests entirely on the close external similarity of the Mexican shells with Rowley's species. Weller indicated that *Ambocoelia levicula* possesses a smooth exterior but the Mexican shells contain hairlike spines. Whether or not Rowley's species is spinose cannot be established here, but the nearly identical external morphology suggests that fine spines might

have been present originally on the specimens studied by Weller, but were not preserved.

Remarks.—The Mexican shells reveal the morphology of the dorsal interior in great detail, and also indicate the presence of a small transverse delthyrial plate in the ventral valve. This latter feature was not noted by George (1931) as occurring in *Crurithyris,* but is so small that it could easily have been unnoticed in the material examined by George. The interior of the complete specimen figured can be seen in part through the open delthyrium and one of the spirals of the lophophore supports is present attached to one of the crura. This specimen confirms the fact that no jugum or jugal processes are present in *Crurithyris.*

Family ATHYRIDAE Davidson, 1884

Genus COMPOSITA Brown, 1849

COMPOSITA OBESA Sanders, new species

Plate 6,C, figures 16-20

Exterior.—Shell about as wide as long, widest at midlength, obese; valves nearly equally convex, the ventral valve with slightly greater convexity; ventral valve with swollen umbone and evenly convex curvature from edge of delthyrium onto lateral slopes, bearing very faint, wide median sulcus; dorsal valve with small umbone, beak slightly incurved, lacking fold; anterior commissure gently and faintly uniplicate.

Dorsal interior.—Dental sockets bounded posterolaterally by wall of valve, with socket floor attaching to posterolateral valve wall just below plane of commissure, curving medially inward and upward; cardinal "process" formed by upward continuation of inner socket plate; crural bases attach to inner socket plate in a plane parallel to and slightly above plane of commissure; hinge plate unsupported, set just below and parallel to plane of crural bases, not extending to umbone, leaving a small triangular visceral foramen just under beak; muscle scars not impressed into shell.

Types.—Holotype, U.S.N.M. 127930a; figured paratypes, U.S.N.M. 127930b, c; unfigured paratypes, U.S.N.M. 127930d,e.

Remarks.—Most Mississippian species of *Composita* have well-defined fold and sulcus, but *C. obesa* shows only faint traces of a sulcus on the ventral valve and no fold on the dorsal valve. The dorsal interiors of the species of *Composita* are poorly known, so the internal features here described cannot be readily compared with those of other species of the genus. The obese appearance of the ventral valve and

faint folding are readily recognized external features of this species. *C. lewisensis* Weller, 1914, closely resembles *C. obesa,* but the latter seems thicker and has a more rounded outline. A large suite of specimens for comparison might show *C. obesa* to merge into *C. lewisensis,* but the two appear distinct on the basis of the available specimens.

Genus "CLEIOTHYRIDINA" Buckman, 1906

The writer's unpublished studies of the British and Belgian Lower Carboniferous brachiopods indicate that the taxonomic status of the genus *Cleiothyridina* is in doubt. Pending publication of a clarification, the name is used here within quotation marks.

Two species of this genus occur in this collection.

"CLEIOTHYRIDINA" GLENPARKENSIS Weller, 1914

Plate 6,A, figures 1-11

1914. *Cleiothyridina glenparkensis* Weller, Geol. Surv. Illinois, Monogr. 1, pp. 473-474, pl. 78, figs. 21-24.

Ventral interior.—Hinge teeth stout; dental plates forming walls of rostral cavity, extending a short distance forward of posterolateral wall of the valve; muscle area faintly impressed, extending to about midlength of valve, bounded laterally by very faint ridges.

Dorsal interior.—Dental sockets with outer margin formed by posterior edge of valve; inner socket plate and fulcral plate continuous, with fulcral plate meeting posterolateral valve wall perpendicularly, curving abruptly upward into inner socket plate; inner socket plate curving upward and posterolaterally, forming half of cardinal "process"; cardinal "process" containing fine parallel muscle striations; hinge plate solid, projecting toward opposite valve at a high angle to plane of commissure, with small visceral foramen between hinge plate and posterior wall of valve and between two halves of cardinal "process"; crural bases attaching to lateral edges of hinge plate, projecting into shell in a plane parallel with hinge plate; muscle area not visible. A faint, low, rounded median ridge occurs in the posterior part of the valve.

Types.—Figured hypotypes, U.S.N.M. 127928a-d.

Discussion.—The dorsal cardinalia of the different genera of the athyrids are poorly known. What is known of these structures by the writer indicates that they are similar in many genera. The jugum, possibly a diagnostic structure, is known in only a few species within this large group of brachiopods, and is not known in *"C." glenparkensis.*

Mexican shells assigned here are a little thicker than the specimen

illustrated by Weller (1914, pl. 78, fig. 23), but otherwise agree in external configuration. The important external features emphasized by Weller in defining this species are the equal convexity of the valves, the rounded to transversely elliptical outline, and the slight median flattening or faint sulcus present on both valves. Weller did not describe the interior details, which are here added from broken specimens which preserve the hinge structures.

"CLEIOTHYRIDINA" species

Plate 6,B, figures 12-15

Two broken specimens of a much larger species than *"C." glenparkensis* are present in this collection. These are nearly as large as the specimens of *"C." incrassata* (Hall) figured by Weller (1914, pl. 79, fig. 12), but are so incomplete that the writer cannot assign them to any species.

Figured specimens.—U.S.N.M. 127929a, b.

Family CYRTINIDAE Stehli, 1954

Genus CYRTINA Davidson, 1858

CYRTINA BURLINGTONENSIS Rowley, 1893

Plate 7,C, figures 9-24

1893. *Cyrtina burlingtonensis* ROWLEY, Amer. Geol., vol. 12, p. 308, pl. 14, figs. 15-17.

1914. *Cyrtina burlingtonensis* WELLER, Geol. Surv. Illinois, Monogr. 1, pp. 288-289, pl. 35, figs. 22-31.

Three specimens of this species occur in the collection, two complete shells and one fragment of a ventral valve. All show clearly the diagnostic spondylium with median septum continued through the united dental lamellae, possibly like the structure Fredericks (1926) called a tichorhinum, but this could not be verified without thin sections. The two complete specimens preserve the deltidium and reveal a large oval pedicle foramen (pl. 7,C, figs. 10, 21, 22). Weller (1914, p. 288) indicates a small foramen for this species. The writer has not seen Rowley's original specimens and cannot compare directly the size of the foramen between the original and these Mexican specimens. Small importance, however, is assigned to the obvious fact that a large foramen occurs in the specimens under study here.

The outline of the two complete specimens differs somewhat, but this is ascribed to difference in age and a slight variation in rate of growth. The early growth stages are distinctly preserved on both

specimens and appear to be very similar. The subconical, erect ventral valve shown in plate 7,C, figure 17, resulted from uniform growth of the whole ventral valve. By contrast, the apsacline profile shown in plate 7,C, figure 11, developed by more rapid growth of the anterior margin, causing the interarea to incline progressively backward in later growth stages.

A fragment of a ventral valve (pl. 7,C, fig. 24) reveals the high median septum and short spondylium, the dental lamellae curving toward the septum close to the cardinal area. Because of the small size of the spondylium and its closeness to the cardinal area, the adductors and diductors may not have been seated within the spondylium, but may have been attached to the sides of the high septum. No muscle markings have been seen to confirm such a view, but it seems likely by reason of the possibility that a large pedicle may have attached to the spondylium and perhaps occupied most of it.

Fredericks (1926) proposed the genus *Davidsonella*,[7] based on *Spirifer septosa* Phillips, 1836, from the British Lower Carboniferous, for cyrtinid shells with special apical plates which he characterized as "spondylium sine tichorino." The completely different external configuration and size of *D. septosa* places it in a different group from the shells here shown. The presence of the "spondylium sine tichorino," which is emphasized as a generic character of *Davidsonina*, may occur in several groups of cyrtinid shells and requires thin sections for verification. The writer therefore declines to assign these Mexican shells to *Davidsonina* because the external morphology of the shells is so different and the interior details of the dorsal valves unknown in both groups.

Types.—Figured hypotypes, U.S.N.M. 127934a-c.

Family SPIRIFERINIDAE Davidson, 1884

Genus PUNCTOSPIRIFER North, 1920

The original diagnosis of *Punctospirifer* was incomplete (North, 1920) and considerable latitude of interpretation has grown up in consequence of this. The genus was diagnosed as consisting of punctate spiriferids which contain a prominent fold and sulcus which is larger than any of the simply rounded lateral costae and which are ornamented over-all by a concentric pattern of imbricate lamellae, and bear a median septum in the ventral valve. Dorsal interior details were not discussed by North, nor was the fine surface ornament.

[7] Homonym, adjusted to *Davidsonina* by Schuchert and LeVene (1929a, p. 120.).

The writer had the opportunity to study the holotype and topotype specimens of *P. scabricosta* North, the genotype species, in the collections of H. M. Geological Survey and the British Museum (Natural History) in London during the winter of 1953-54, and has elsewhere discussed the results of these observations (Sanders, in preparation). The Mexican collection contains excellent material for illustrating some of the features not described by North. With the additional observations, the following revised and extended diagnosis of *Punctospirifer* is possible:

Punctate spiriferids with fold and sulcus wider than any of simple costae; both valves ornamented by regular pattern of concentric imbricating lamellae, each lamella bearing fine, hairlike spines which lie flat in the plane of the lamella. Ventral interior with median septum ending posteriorly in an apical callosity. Dorsal interior with pillarlike thickening supporting cardinal process, the pillar dividing anteriorly into stout rounded ridges which bound the muscle field laterally; muscle field bisected by low rounded median ridge. Crural bases projecting anteriorly from posterior pillar, attached to inner socket plates by crural connecting plates. Primary lamellae joined by U-shaped jugum.

Distinguishing characters.—The important features of *Punctospirifer* are the width of the rounded fold and sulcus compared to the lateral costae, concentric imbricating lamellae bearing hairlike spines, median septum and apical callosity in ventral valve, and the nature of the dorsal cardinalia. The elements of the dorsal interior are simple and superficially similar in most spiriferinids. Careful study reveals different patterns of arrangement, however, and *Punctospirifer* can be recognized readily on these features alone after some experience.

PUNCTOSPIRIFER SULCIFER, Sanders, new species

Plate 7,D, figures 25-30

Diagnosis.—*Punctospirifers* about twice as wide as long, widest at hinge line, with acute cardinal extremities; costae on both valves slightly flattened on top; bearing fold on ventral valve which contains a median sulcus.

Exterior.—Shell spiriferoid, about twice as wide as long, widest at hinge, cardinal extremities acute, front margin semicircular; valves subequally convex, the ventral valve having greater convexity, nearly subpyramidal, with greatest depth at umbone; dorsal valve gently convex, deepest at midpoint; ventral interarea gently concave, apsacline curving gently backward to slightly incurved beak, sharply defined

from lateral slopes; dorsal interarea very small, orthocline, curving gently posteriorly; sulcus of ventral valve narrowly rounded, well defined at beak, widening anteriorly; fold of dorsal valve steep sided, widening regularly forward, bearing small median sulcus; anterior commissure uniplicate; lateral slopes of each valve bearing six to eight simple, narrowly rounded costae separated by similarly shaped furrows; surface covered by regular pattern of closely spaced, concentric imbricate lamellae, each lamella bearing fine hairlike spines lying flat in the plane of the lamella. Shell coarsely punctate.

Ventral interior.—Hinge teeth curving gently inward toward median plane; dental plates slightly divergent, attaching to floor of valve along first furrow outside sulcus, extending about one-fourth the distance to the front margin, united posteriorly by small apical callosity; median septum extending from apical callosity to about midlength, distal edge parallel to convexity of valve, curving abruptly at forward edge. No muscle marks seen.

Dorsal interior.—Notothyrium bounded by thickened inner socket plates; dental sockets defined at umbone, widening anterolaterally, bounded posterolaterally by palintrope, whose inner edge slightly overhangs outer portion of each groove; floor of dental sockets formed by fulcral plate extending from posterior wall of valve to inner socket plate parallel to palintrope; cardinal process spiriferoid, supported by pillarlike thickening at posterior of valve; pillar diverging anteriorly into two stout, low, rounded ridges bounding the muscle field laterally and extending forward along edge of fold about halfway to front margin, and a low, rounded median ridge extending about three-fifths of the way to the front margin; crural bases diverging forward from pillar at base of cardinal process at the same angle as ridges bounding muscle field, attached to thickened inner socket plate by thin crural connecting plate, not otherwise supported. No adductor muscle marks seen.

Types.—Holotype,U.S.N.M. 127935a; figured paratypes, U.S.N.M. 127935b-d.

Distinguishing characters.—*Punctospirifer sulcifer* differs from the previously described species of *Punctospirifer* by its median sulcus on the dorsal fold. Other punctate spiriferids from the Mississippian of the Upper Mississippi Valley described by Weller (1914, pp. 292, 295) which possess imbricate concentric lamellae are *"Spiriferina" subtexta* White and *"Spiriferina" subelliptica* (McChesney). The general configuration of these two species is sufficiently distinct from *P. sulcifer* to prevent confusion. Until the interior details of the above-

cited *"Spiriferinas"* are known, their proper generic assignment cannot be made with confidence.

PUNCTOSPIRIFER GLOBOSA Sanders, new species

Plate 7,E, figures 31-36

Description.—Shells about as long as wide, widest just forward of the hinge line; cardinal extremities acute; bluntly rounded; lateral profile rotund, valves about equally biconvex, both being deepest at about midlength; ventral interarea nearly orthocline, gently concave, rounding broadly onto lateral slopes; beak slightly overhanging; each lateral slope bearing four or five simple rounded costae separated by furrows of similar shape; ventral sulcus well defined at the beak, widening gradually toward the front, containing a faint median costa from the umbone forward; dorsal fold similarly bearing a median sulcus; surface ornamented by concentric imbricate lamellae which bear hairlike spines. Shell coarsely punctate.

Types.—Holotype, U.S.N.M. 127936a; unfigured paratypes, U.S.N.M. 127936b.

Remarks.—This species differs from *P. sulcifer* in its much narrower valves, the strong costa in the sulcus of the ventral valve and the strongly incurved ventral beak.

Family RHYNCHOSPIRINIDAE Schuchert and LeVene, 1929

Genus HUSTEDIA Hall and Clarke, 1894

HUSTEDIA CIRCULARIS (Miller), 1892

Plate 5,F, figures 23-26

1892. *Retzia circularis* Miller, Adv. Sheets, 18th Rep. Geol. Surv. Indiana, p. 62, pl. 9, figs. 32, 34.

1914. *Hustedia circularis* Weller, Geol. Surv. Illinois, Monogr. 1, pp. 451-452, pl. 76, figs. 47-52.

Two small specimens similar to the shells assigned to *H. circularis* (Miller) by Weller occur in this collection. The internal characters are unknown so the generic assignment is subject to the same uncertainty expressed by Weller (1914, p. 452).

Types.—Figured hypotypes, U.S.N.M. 127920a, b.

PELECYPODA

Genus PARRALLEDON Meek and Worthen, 1866

PARALLELODON SULCATUS Weller, 1906

Plate 3,D, figures 23-25

1906. Weller, S., Trans. St. Louis Acad. Sci., vol. 16, pp. 450-451, pl. 2, figs. 6-9.

A single right valve of a *Parallelodon* is referred to *P. sulcatus* Weller.

Figured specimen.—U.S.N.M. 127912a.

Genus CONOCARDIUM Bronn, 1834

CONOCARDIUM species

Plate 3,E, figures 26-29

Several well-preserved specimens of a *Conocardium* species occur in the collection. The hinge details are obscured by silicification.

Figured specimen.—U.S.N.M. 127913.

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GASTROPODA

By J. Brookes Knight
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(Plates 8,A-J, and 9,A; text figure 4)

INTRODUCTION

The Mississippian collection comes from the Represo formation at Bisani, Sonora, Mexico. From them I am able to identify nine genera or subgenera. The startling thing about this gastropod fauna is that its affinities are with the lower Carboniferous faunas of England, Ireland, and northwestern Europe and very little with the better known Mississippian faunas of the United States or Nova Scotia. The meaning of this is difficult to interpret with the little information available to me. Although the time factor may enter into the question it seems to me that so striking a resemblance in general terms is more likely due to facies, a facies in Mexico much more similar to that of northwest Europe than to that of the Mississippi Valley and northern Rocky Mountains from which come the richest and best-known gastropod faunas of the American Mississippian. Considering the time aspect these American faunas are of middle or possibly early upper Mississippian age.

At first glance it may seem significant that two of the gastropod genera from Mexico, *Platyschisma* and *Phanerotinus,* are represented in the United States only in the little-known gastropod fauna of the lower Mississippian Northview shale. But the force of this coincidence is greatly weakened by the range of both genera throughout both the Tournaisian and Viséen in Belgium. However, the fact that both *Platyschisma* and *Phanerotinus* occur only in the lower Mississippian so far as is known in North America coupled with the close affinity of one of the species of *Baylea* with *B. yvanii* of the Belgian Tournaisian suggests that the Mexican fauna is also of early Mississippian age.

SYSTEMATICS

BELLEROPHON species

Plate 8,A, figures 1, 2

The collection includes three small specimens of a species of *Bellerophon,* probably juveniles. Except that the species has no umbilici there is nothing very much that one can say about it, and even this has

little significance. The genus *Bellerophon* is abundant throughout the world in rocks from Devonian to Permian age at least and its actual range is even a little greater. The species can neither be identified nor described from the material at hand.

Figured specimen.—U.S.N.M. 127988a.

BAYLEA aff. B. YVANII (Leveillé), 1835

Plate 8,B, figures 3-6

This is a turreted pleurotomarian with the slit and selenizone just within the outer margin of the whorl shoulder. In respect to its narrow pleural angle (about 50°) and its exclusively even revolving ornamentation it is very close indeed to the genotype, *B. yvanii* (Leveillé) from Tournai, Belgium, as identified by de Koninck in 1883. There is a possibility that it is identical with the Belgian species but with only the old and inadequate literature as a basis for judgment it is impossible to be certain.

It is interesting to note that this and the following species are the only two species of the genus *Baylea* as yet to be recorded from Mississippian beds in the Western Hemisphere although somewhat advanced species occur throughout the Pennsylvanian and even Permian beds of the United States. It is above all interesting that the affinities of both Mexican species are with those of the European Mississippian forms and not with the hitherto recognized forms from the American Pennsylvanian or Permian.

Figured specimens.—U.S.N.M. 127986a, b.

BAYLEA species

Plate 8,G, figures 15-16

A somewhat less-turreted species than the foregoing with a wider pleural angle (about 61°). It has a narrower whorl shoulder and fewer revolving lirae. However, its slit and selenizone are just within the margin of the shoulder as is characteristic for the genus. Although it is clearly of the group within the genus that occurs only in Mississippian rocks, a group that includes the genotype, it is not closely comparable with any described species. The material, a single specimen, is too poor to form a basis for a newly described species.

Figured specimen.—U.S.N.M. 127984.

BORESTUS species

Plate 8,C, figures 7, 8

This species is represented by a single rather poor specimen but seems clearly referable to *Borestus* Thomas, 1939. Although the geno-

type of *Borestus* and several other species were derived from late lower Carboniferous beds in Scotland the species is not close enough to European species to warrant detailed comparisons. The genus ranges throughout the Pennsylvanian in the United States and possibly into the lower Permian but is known from Mississippian beds only in Europe. The single specimen is too poorly preserved to employ it as the basis for describing a new species.

Figured specimen.—U.S.N.M. 127987.

RHINEODERMA cf. R. NYSTII de Koninck, 1883

Plate 8,E, figures 10, 11

This species is clearly referable to the genus *Rhineoderma* Koninck 1883 and appears to resemble most closely *R. nystii* de Koninck from Assiz III. However, it is impossible to establish either identity or close affinity, for not only is the Mexican specimen badly preserved in its details but de Koninck's dsecriptions and figures are inadequate. *Rhineoderma* ranges throughout the Belgian lower Carboniferous and is represented by several species in the American middle Mississippian Salem and Brazer limestones. It shows no close affinities with the species from the United States. It has not been reported from the Pennsylvanian or younger beds anywhere.

Figured specimen.—U.S.N.M. 127985.

PLATYSCHISMA species

Plate 8,H, figures 17-19

This species is a typical representative of the genus *Platyschisma*, 1844, hitherto authentically known only from Europe where it ranges throughout the lower Carboniferous and from the Northview sandstone of Kinderhookian age in the United States. The reported Devonian occurrences refer to what is now regarded as a different and not closely related genus. Again, on account of the poor preservation of the Mexican material it is impossible to do more than identify the genus.

Figured specimen.—U.S.N.M. 127990a.

STRAPAROLUS (EUOMPHALUS) species A

Plate 8,I, figures 20, 21

This species is a typical member of the subgenus *Euomphalus*. *Euomphalus* has a long range in the late Paleozoic (Devonian-Permian) and few faunas of Mississippian, Pennsylvanian, or Permian

age of both hemispheres are without one or more species. Because of the great similarity between numerous species one needs the best of specimens, preferably many of them, to make positive identifications. Although the specimens in the Mexican collection are more numerous than those of other species and somewhat better preserved, specific identification or description is not warranted.

Figured specimen.—U.S.N.M. 127983a.

STRAPAROLUS (EUOMPHALUS) species B

Plate 8,D, figure 9

This species is a member of the group for which de Koninck in 1881 proposed the name *Phymatifer.* However, in respect to the characters that are supposed to distinguish *Phymatifer* from *Euomphalus,* evenly spaced tubercles on the upper and lower angles of the whorl, there is the most complete intergradation. Consequently, I regard the name as a junior synonym of the subgeneric name *Euomphalus* Sowerby (Knight, 1934, p. 114).[1] The phymatiferoid euomphalids are also widespread and long ranging. The single specimen in the Mexican collections is far too imperfect for more than subgeneric identification.

Figured specimen.—U.S.N.M. 127982.

PHANEROTINUS cf. P. PARADOXUS Winchell

Plate 8,J, figure 22

This openly coiled straparolid genus is abundant in the European lower Carboniferous but is almost unknown in the Mississippian of the United States. The sole recorded occurrence in the United States is in the Northview sandstone, Kinderhookian, where a species very similar to the Mexican species has been described. Neither the Mexican specimens nor the description or figures of the species described are adequate for precise identification.

Figured specimen.—U.S.N.M. 127989a.

PLATYCERAS (PLATYCERAS) species A

Plate 9,A, figures 1-5

The collections contain some 15 specimens of platyceratids which, as is usual in this genus of stationary life habit, are highly variable in respect to details of shape and of the apertural margin. All but one

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[1] Knight, J. B., The gastropods of the St. Louis, Missouri, Pennsylvanian outlier: VII. The Euomphalidae and Platyceratidae. Journ. Paleont., vol. 8, No. 2, pp. 139-166, 1934.

specimen have the hooked apex of the subgenus *Orthonychia,* but one has the coiled apex of the typical subgenus. This specimen differs from all the others, moreover, in that at maturity its margin on the right side was produced periodically into a gutterlike spine. Beside the spine that was open at the apertural margin four other abandoned spines, or their broken bases, can be counted in a row above it. The earlier half of the whorl was spineless. Other than growth lines and the spines the shell is without ornamentation. The growth lines delineate irregularities of the apertural margin which seem to reflect irregularities of the object to which it was attached, presumably a crinoid calyx. I am unable to assign any definite function to the periodic gutterlike spines on this or on other species of *Platyceras* that bear them.

Platyceras (s.l.) has a long range, Silurian-Permian, and is usually abundant where crinoids are present. In facies without crinoid remains *Platyceras* is also absent. Unless species are characterized by distinctive ornamentation most of them are very difficult to discriminate and have little value for time correlations.

Figured specimen.—U.S.N.M. 127992.

PLATYCERAS (ORTHONYCHIA) species A

Plate 8,F, figures 12-14

This species has the hooked apex of the subgenus *Orthonychia* instead of the coiled apex of *Platyceras* (s.s.). In all other respects the two subgenera are very similar and had similar habits. Unlike the foregoing species this one does not bear a row of spines. Like it, it is without finer ornamentation other than growth lines and on this account it is very difficult to characterize. Specimens of both species are of about the same size and general form but the form in both is quite variable.

Figured specimens.—U.S.N.M. 127993a, b.

CEPHALOPODA

By Arthur K. Miller
University of Iowa

(Plate 9,B)

TRIBOLOCERAS DIGONUM (Meek and Worthen)

Plate 9,B, figures 6-8; text figure 4

1860. *Nautilus* (*Discus*) *digonus* Meek and Worthen, Proc. Philadelphia Acad. Nat. Sci., p. 470.
1866. *Nautilus* (*Trematodiscus*) *digonus* Meek and Worthen, Geol. Surv. Illinois, vol. 2, pp. 163-164, pl. 14, figs. 9a-9e.
1889. *Trematodiscus digonus* Miller, North American geology and palaeontology . . . , p. 455. Cincinnati.
1893. *Triboloceras* (*Tremat.*) *digonum* Hyatt, Texas Geol. Surv., Ann. Rep. 4, pp. 418-419.
1894. *Nautilus digonus* Keyes, Missouri Geol. Surv., vol. 5, p. 222.
1898. *Triboloceras digonum* Weller, U. S. Geol. Surv. Bull. 153, p. 635.
1899. *Triboloceras digonum?* Weller, Trans. St. Louis Acad. Sci., vol. 9, pp. 45-46, pl. 5, figs. 17, 18.
1901. *Triboloceras digonum* Weller, Journ. Geol., vol. 9, p. 143.
1928. *Triboloceras digonum* Moore, Missouri Bur. Geol. and Mines, ser. 2, vol. 21, pp. 66, 68, 95, 100, 104, 124.
1929. *Coelonautilus* (*Triboloceras*) *digonus* Schmidt, Tierische Leitfossilien des Karbon, Gürich's Leitfossilien, Lief. 6, p. 58, pl. 14, figs. 5, 6.
1939. [1938]. *Triboloceras digonum* Miller and Furnish, Missouri Univ. Studies, vol. 13, No. 4, pp. 149, 150, 153-156, pl. 39, figs. 1-11; pl. 40, figs. 2-8; pl. 41, figs. 3, 4; pl. 43, fig. 5; pl. 45, fig. 4.
1947. *Triboloceras digonum* Miller and Youngquist, Journ. Paleont., vol. 21, pp. 113, 114, 115, pl. 27, figs. 5, 6.
1949. *Triboloceras digonum* Miller, Downs, and Youngquist, Journ. Paleont., vol. 23, pp. 602, 603, 607, pl. 97, figs. 6, 7; pl. 99, figs. 12-15.

A single representative of this well-known somewhat variable species was obtained in Sonora. It is entirely silicified, slightly distorted, not very well preserved, and incomplete both adapically and adorally.

This specimen represents about three-quarters of a volution of the loosely coiled adapical portion of the conch. Near its adapical end (which is poorly preserved) it appears to have been more or less subcircular or subelliptical in cross section and to have had a diameter of something like 6 or 7 mm. However, it is rapidly expanded orad, particularly in a lateral direction, and near its adoral end is almost

semicircular in cross section as it is nearly flat (slightly convex) ventrally, subangular laterally, and broadly rounded dorsally. The maximum height and width attained by the preserved portion of the conch measure about 15 mm. and 27 mm. respectively.

On the surface of the specimen there are prominent angular longitudinal ridges which are separated by relatively wide, broadly rounded grooves. It is estimated that on the adoral part of the specimen there are some 15 of these ridges on the flattened ventral portion of the conch and some 20 of them on the corresponding rounded dorsal portion. The nature of the sutures and the siphuncle cannot be ascertained, though near the midlength of the specimen there are traces of transverse structures that may represent septa.

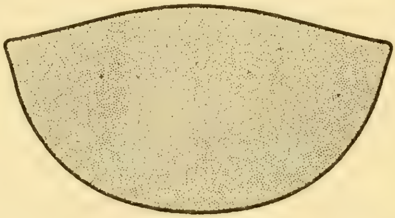

FIG. 4.—*Tribolocerus diconum* (Meek and Worthen). Diagrammatic cross section of the adoral portion of the specimen represented by figures 6-8 on plate 9, B, $\times$ 2.

Remarks.—This species was originally described from the Rockford limestone of Indiana, and it has since been found to be of widespread occurrence in the Chouteau limestone (and the Northview shale) of Missouri, equivalent beds in Illinois, the Caballero formation of New Mexico, and the upper part of the Redwall limestone of Arizona. With the possible exception of the last, the containing strata in each case are Kinderhookian in age. Miller and Furnish divided the Missouri representatives of this species into six varieties, and the Sonora individual appears to be referable to their most abundant form, *T. d. semicirculare,* in which also belong the few specimens known from New Mexico and Arizona. It seems likely that all these individuals lived in a Kinderhookian sea that extended from Indiana southwest across Illinois and Missouri to New Mexico, Arizona, and Sonora.

Occurrence.—Represo beds, small hill 1½ miles north-northwest of Bisani, Sonora, Mexico.

Figured specimen.—U.S.N.M. 127991.

EXPLANATION OF PLATES

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Plate 1

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Figs. 1-3.—*Rotiphyllum occidentale* Easton........................... 20

1, Calyx, × 3, paratype, U.S.N.M. 127947. 2, Corallite, side view, × 1, holotype, U.S.N.M. 127946. 3, Calyx, × 3, holotype.

Figs. 4, 7-9.—*Triplophyllites* (*Homalophyllites*) *circularis* Easton....... 22

4, Natural transverse section, × 3, paratype, U.S.N.M. 127945b. 7, Calyx, × 3, holotype, U.S.N.M. 127944. 8, Corallite, side view, × 1, holotype. 9, Calyx, × 3, paratype, U.S.N.M. 127945a.

Figs. 5, 6.—*Caninia corniculum* (Miller) emend. Easton............... 27

5, Calyx, × 1, hypotype, U.S.N.M. 127948. 6, Side view of same specimen, × 1.

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Figs. 11, 20, 24.—*Cystelasma invaginatum* Easton..................... 33

11, Calyx, × 3, paratype, U.S.N.M. 127942. 20, Side view showing theca, × 1, holotype, U.S.N.M. 127941. 24, Weathered section showing steeply tilted tabulae, × 1, holotype.

Fig. 12.—*Lithostrotionella confluens* Easton.......................... 31

Surface of small colony, × 1, partype, U.S.N.M. 127938.

Figs. 13, 21.—*Trochophyllum* (*Trochophyllum*) species................ 17

13, Calyx, × 3, U.S.N.M. 127949. 21, Side view, × 1, same specimen.

Figs. 14, 17, 18.—*Cyathaxonia cordillerensis* Easton.................... 13

14, Calyx, × 3, holotype, U.S.N.M. 127950. 17, Calyx, × 3, paratype, U.S.N.M. 127951. 18, Side view of holotype, × 1.

Figs. 15, 16.—*Pleurodictyum subramosum* Easton.................... 37

15, Side view showing mural pores at uppermost tip of figure, × 1, holotype. 16, Surface, × 1, holotype. U.S.N.M. 127940.

Figs. 19, 23.—*Trochophyllum* (*Barrandeophyllum*) species............. 18

19, Side view, × 1, U.S.N.M. 127952. 23, Calyx, × 3, same specimen.

Fig. 22.—*Syringopora tubifera* Easton................................ 38

Corallum, × 1, paratype, U.S.N.M. 127955a.

Fig. 25.—*Rotiphyllum vesiculosum* Easton............................ 21

Oblique calical view showing dissepiments, × 2, holotype, U.S.C. 4067.

Plate 2

Figs. 1-4.—*Caninophyllum sonorense* Easton.......................... 29

1, Transverse thin section in mature stage, somewhat decorticated, × 2, paratype, U.S.C. 4226. 2, Transverse polished surface in young stage, × 1, holotype, U.S.C. 4225. 3, Transverse polished surface in mature stage, × 2, holotype, U.S.C. 4225. 4, Calyx, × 1, paratype, U.S.C. 4229.

PLATE 3

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Figs. 28-30, Dorsal, posterior, and lateral views, all $\times 1$, hypotype, U.S.N.M. 127921b.

Figs. 31, 32, Ventral interior, $\times 1$, and the same $\times 2$, showing delthyrial cavity, hinge teeth, dental plates, and muscle attachment area, hypotype, U.S.N.M. 127921c.

Fig. 33, Ventral interior, $\times 2$, showing transverse delthyrial plate and faintly impressed muscle area, hypotype, U.S.N.M. 127921d.

Figs. 34, 35, Lateral and enlarged views of a broken specimen showing spiralia, hypotype, U.S.N.M. 127921e.

Figs. 36, 37, Interior of a fragmentary dorsal valve, showing cardinalia (note fulcral plates and crural connecting plates). 37, $\times 2$. Hypotype, U.S.N.M. 127921f.

Plate 6

A.—"*Cleiothyridina*" *glenparkensis* Weller............................ 62

Figs. 1-4, 9. 1-4, Ventral, dorsal, posterior, and lateral views of a broken specimen, all $\times 1$, hypotype, U.S.N.M. 127928a. 9, Dorsal view of same, $\times 2$, showing spiny frills.

Figs. 5-7, Dorsal, posterior, and lateral views of a nearly complete specimen, all $\times 1$, hypotype, U.S.N.M. 127928b.

Fig. 8, Ventral exterior of an incomplete valve, showing spiny frills, $\times 2$, hypotype, U.S.N.M. 127928c.

Figs. 10, 11, Dorsal interior, showing sockets, hinge plate, and visceral foramen, and the same, tilted to show relation of hinge plate to inner socket plates, both $\times 3$, hypotype, U.S.N.M. 127928d.

B.—"*Cleiothyridina*" species 58

Figs. 12, 13, Dorsal and lateral views of a broken specimen, $\times 1$, U.S.N.M. 127929a.

Figs. 14, 15, Ventral and lateral views of a slightly crushed specimen, $\times 1$, U.S.N.M. 127929b.

C.—*Composita obesa* Sanders, new species.......................... 61

Figs. 16-18, Ventral, dorsal, and lateral views of the holotype, all $\times 1$, U.S.N.M. 127930a.

Fig. 19, Dorsal interior of a nearly complete valve, showing radiating straight pallial markings, sockets, divided hinge plate, and visceral foramen, $\times 3$, paratype, U.S.N.M. 127930b.

Fig. 20, Interior view of a broken specimen, showing hinge teeth in articulation position, dental plates, and delthyrial cavity (below), and sockets, inner socket plates, hinge plate, and crural bases (above), $\times 2$, paratype, U.S.N.M. 127930c.

D.—*Reticularia cooperensis* (Swallow)............................. 58

Figs. 21, 22, 30, Exterior and interior views of a fragmentary ventral valve, all $\times 1$. 30, Tilted to show dental plates and median ridge. Hypotype, U.S.N.M. 127931a.

Figs. 23-27. 23, Dorsal exterior, $\times 1$. 25, The same, $\times 2$, showing concentric rows of "double-barreled" spine bases. 24, Dorsal interior, $\times 1$. 26, 27, The same, $\times 2$, showing cardinalia and median ridge, 27 tilted to show support under cardinal process. Hypotype, U.S.N.M. 127931b.

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Fig. 28, Dorsal interior of a fragmentary valve, × 2, showing clublike inner socket plates, crural bases, crural connecting plates, cardinal process, and its flangelike support, hypotype, U.S.N.M. 127931c.

Fig. 29, Ventral interior of a fragmentary specimen, showing teeth, dental plates, and low median ridge, × 2, hypotype, U.S.N.M. 127931d.

PLATE 7

A.—*Tylothyris?* species 57

Figs. 1, 2, Exterior and interior views of a nearly complete dorsal valve, showing median furrow in fold, simple costae, and concentric imbricate lamellae, both × 1, U.S.N.M. 127932.

Fig. 3, Interior view of a portion of the same, showing median ridge, cardinal process, crural bases, crural connecting plates, and clublike termination of inner socket plates, × 2.

B.—*Crurithyris levicula* (Rowley) 60

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Fig. 8, Dorsal interior of a fragmentary valve, showing large, clublike cardinal process, shelflike sockets, and large crural connecting plates, × 4, hypotype, U.S.N.M. 127933b.

C.—*Cyrtina burlingtonensis* Rowley 63

Figs. 9-13, Ventral, dorsal, lateral, anterior, and posterior views of a complete specimen, all × 2, hypotype, U.S.N.M. 127934a.

Figs. 14, 22, Dorsal view of the same, × 1, and dorsal view of the same showing perforate deltidial covering, × 3.

Figs. 15-19, Ventral, dorsal, lateral, anterior, and posterior views of a complete specimen, all × 2, hypotype, U.S.N.M. 127934b.

Fig. 20. Dorsal view of the same, × 1.

Fig. 21. Posterior view of the same, showing perforate deltidial covering and median septum extending through spondylium, × 3.

Figs. 23, 24, Interior views of a fragmentary ventral valve showing median septum continued through small spondylium, × 2, hypotype, U.S.N.M. 127934c.

D.—*Punctospirifer sulcifer* Sanders, new species 65

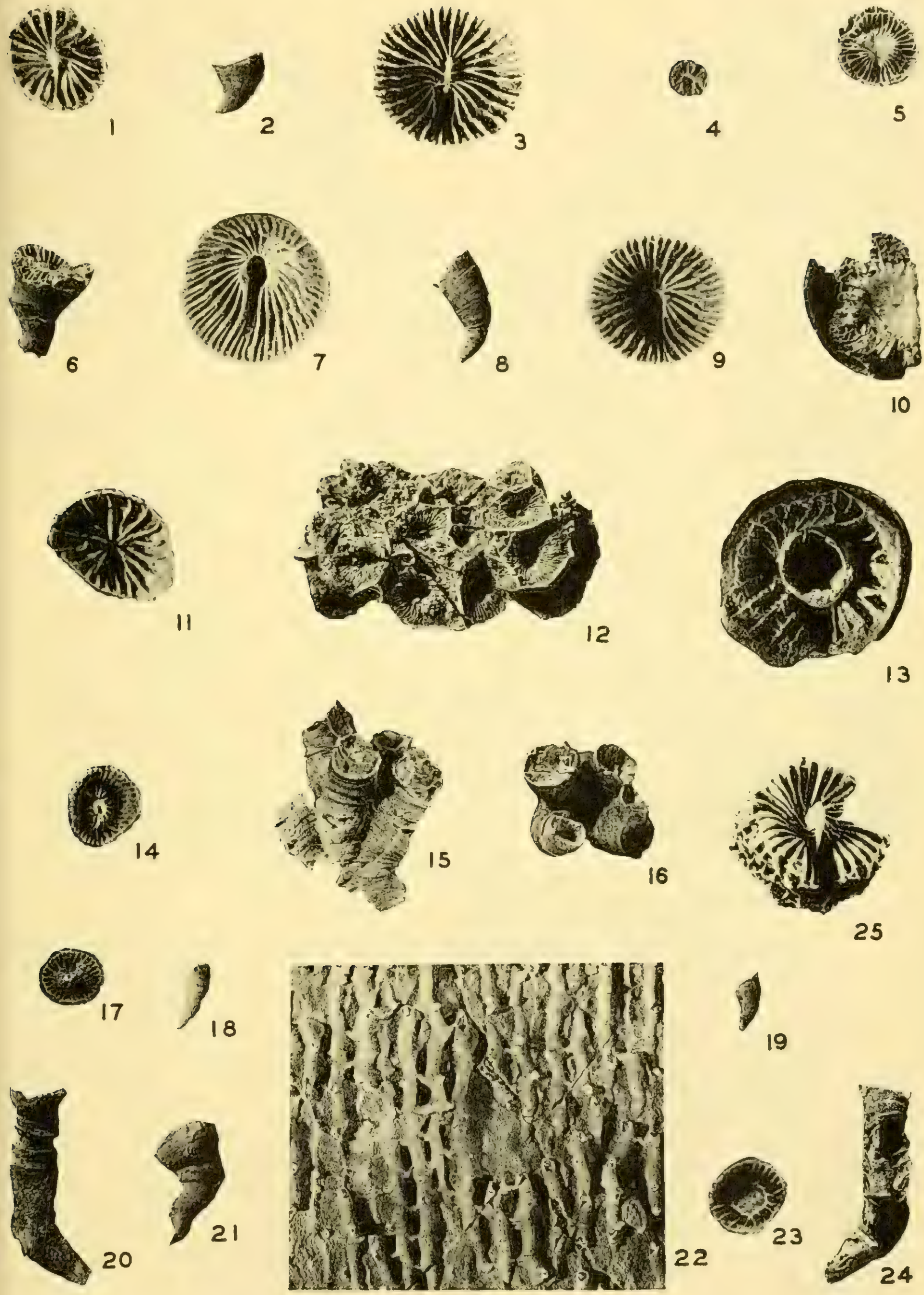
Figs. 25, 27, Dorsal exterior, × 1, and the same, × 2, showing median sulcus in fold and imbricate lamellae bearing hairlike spines, holotype, U.S.N.M. 127935a.

Figs. 26, 28, Ventral interior, × 1, and the same, × 2, showing median septum and coarsely punctate shell structure, paratype, U.S.N.M. 127935b.

Fig. 29, Exterior of a fragmentary ventral valve, showing imbricate lamellae, × 2, paratype, U.S.N.M. 127935c.

Fig. 30, Interior of a fragmentary dorsal valve, × 2, showing cardinal process, sockets, crural bases, crural connecting plates, median ridge, and ridges bounding muscle field, paratype, U.S.N.M. 127935d.

PLATES



MISSISSIPPIAN CORALS FROM NORTHWESTERN SONORA

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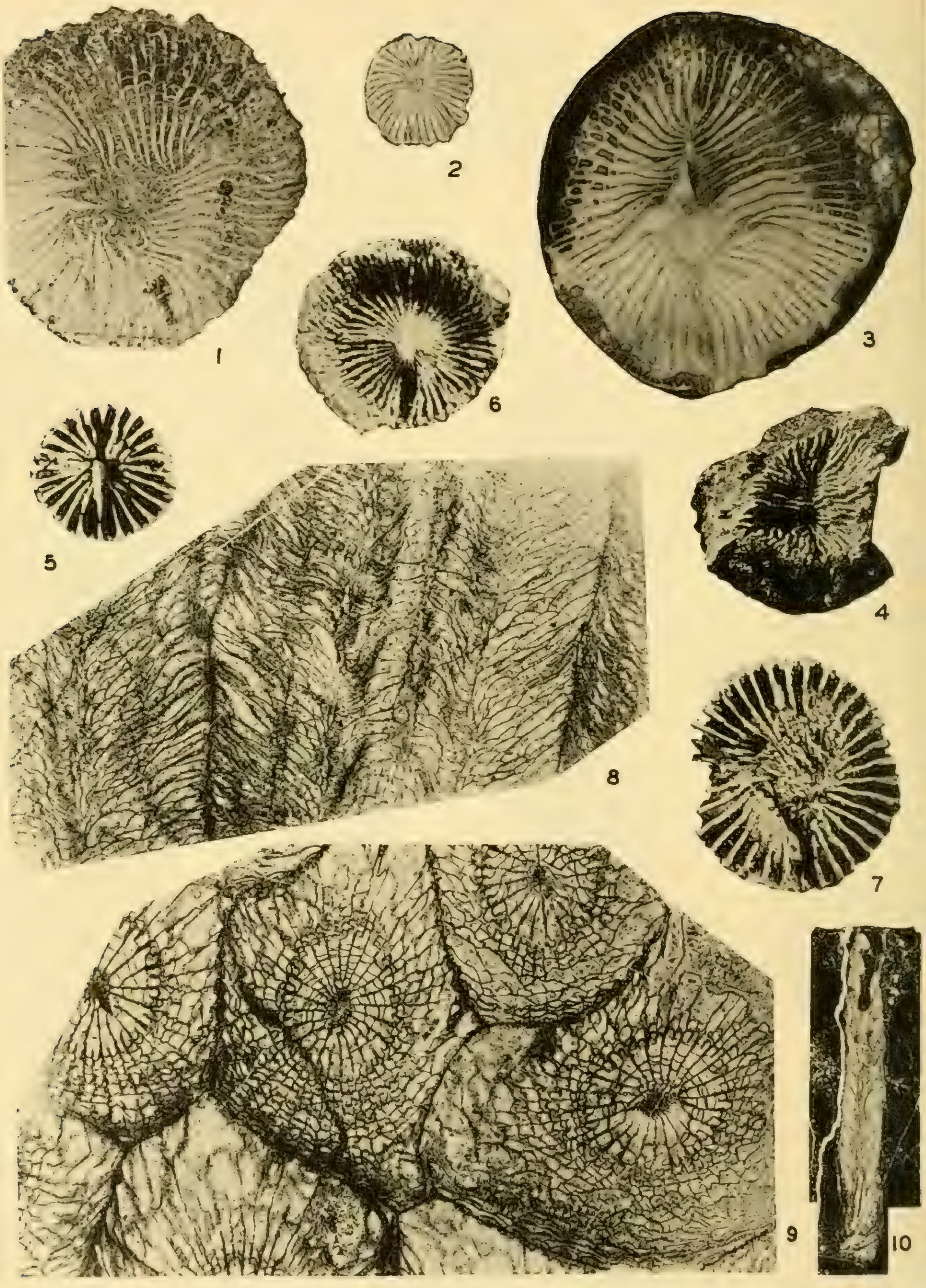
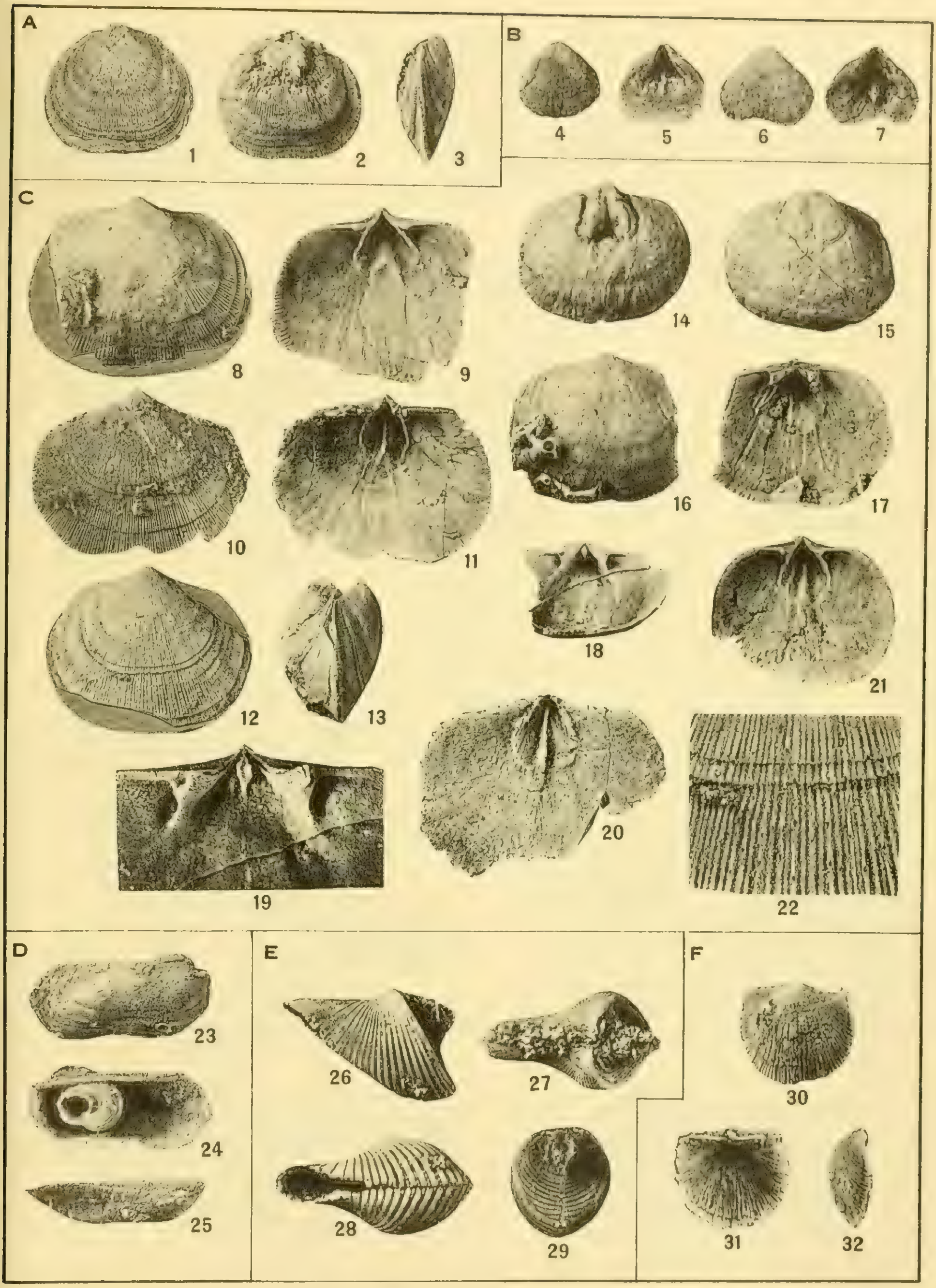


Mississippian Corals from Northwestern Sonora

(See explanation at end of text)



BRACHIOPODA AND PELECYPODA

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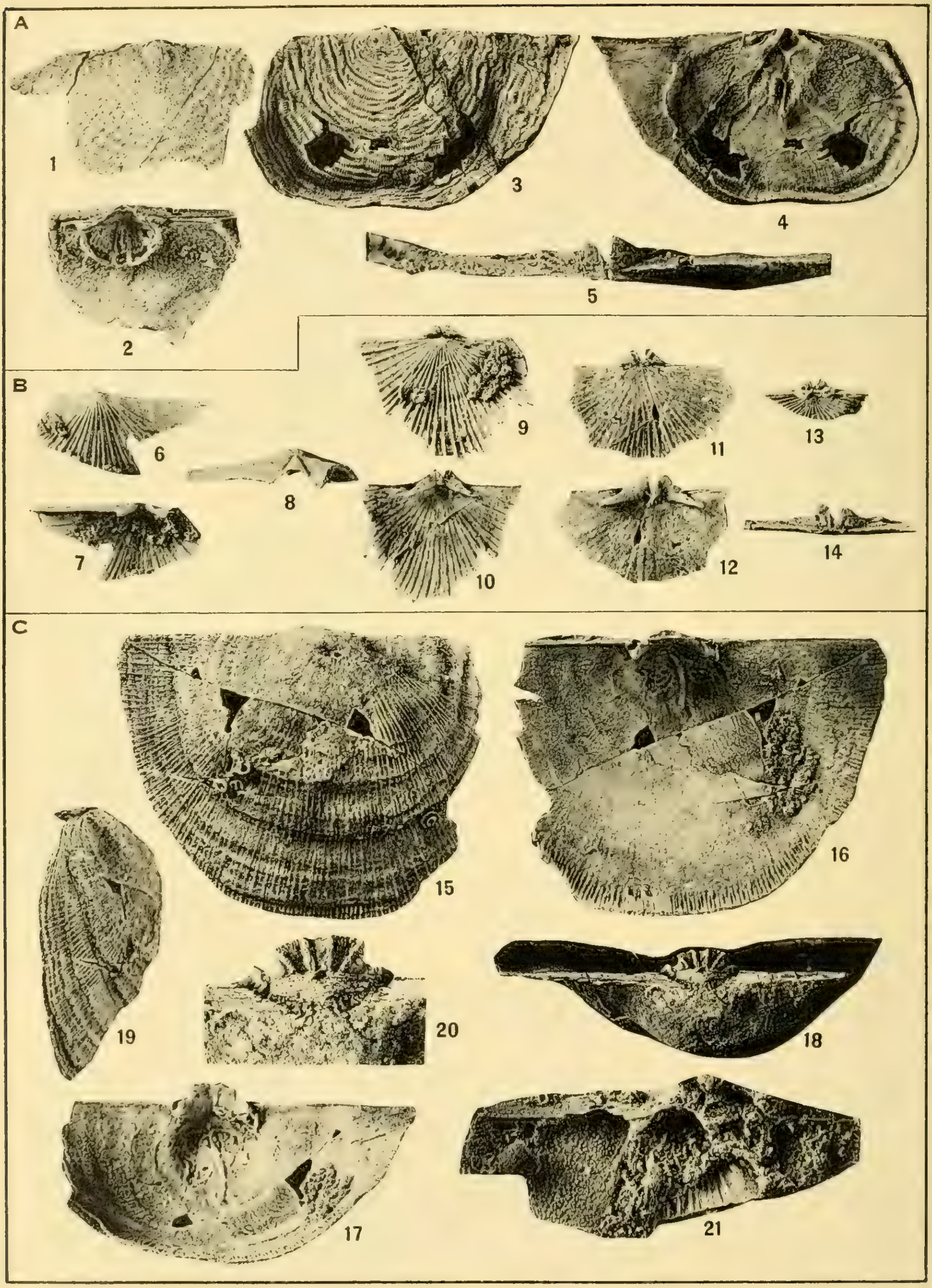
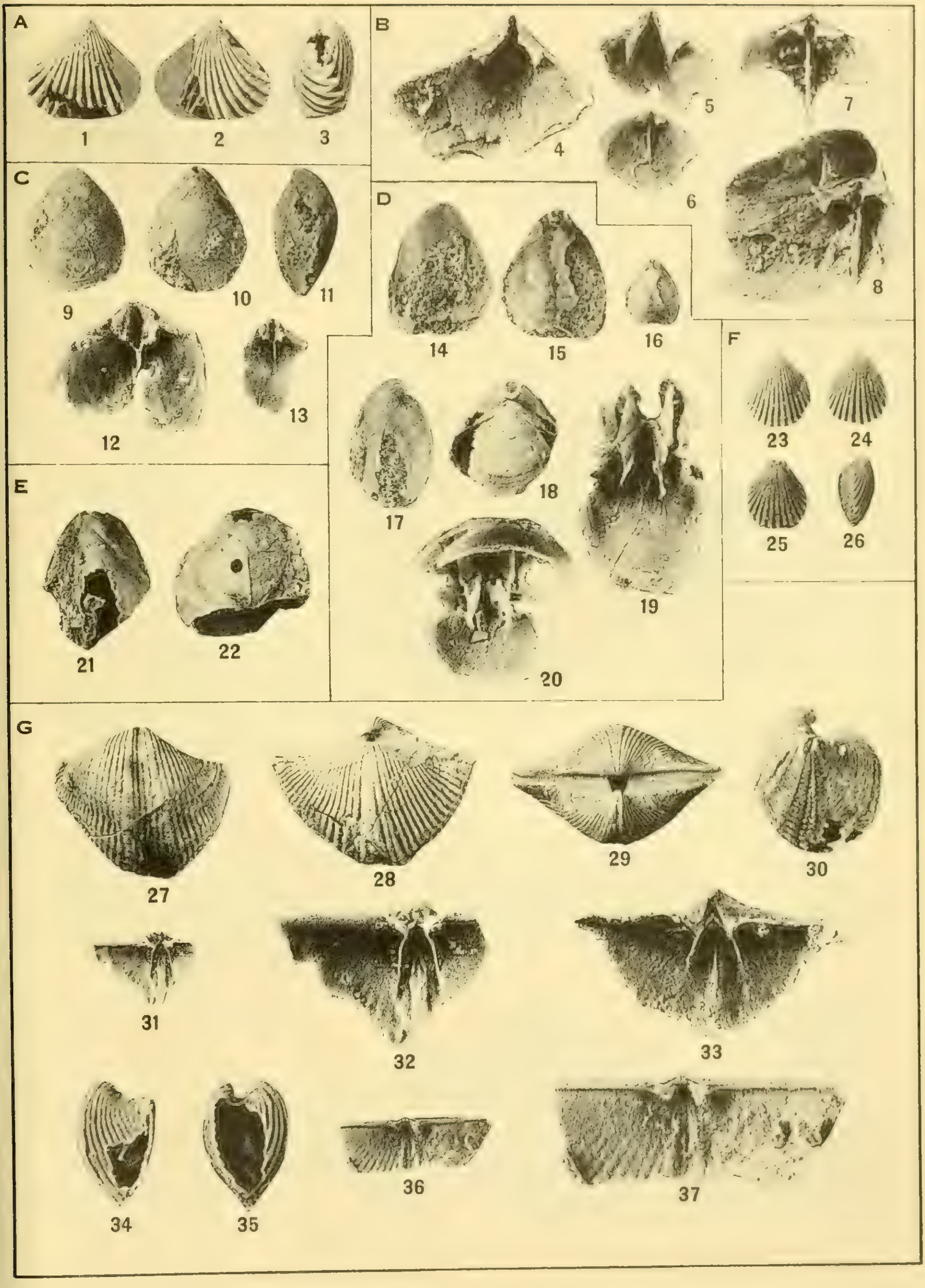


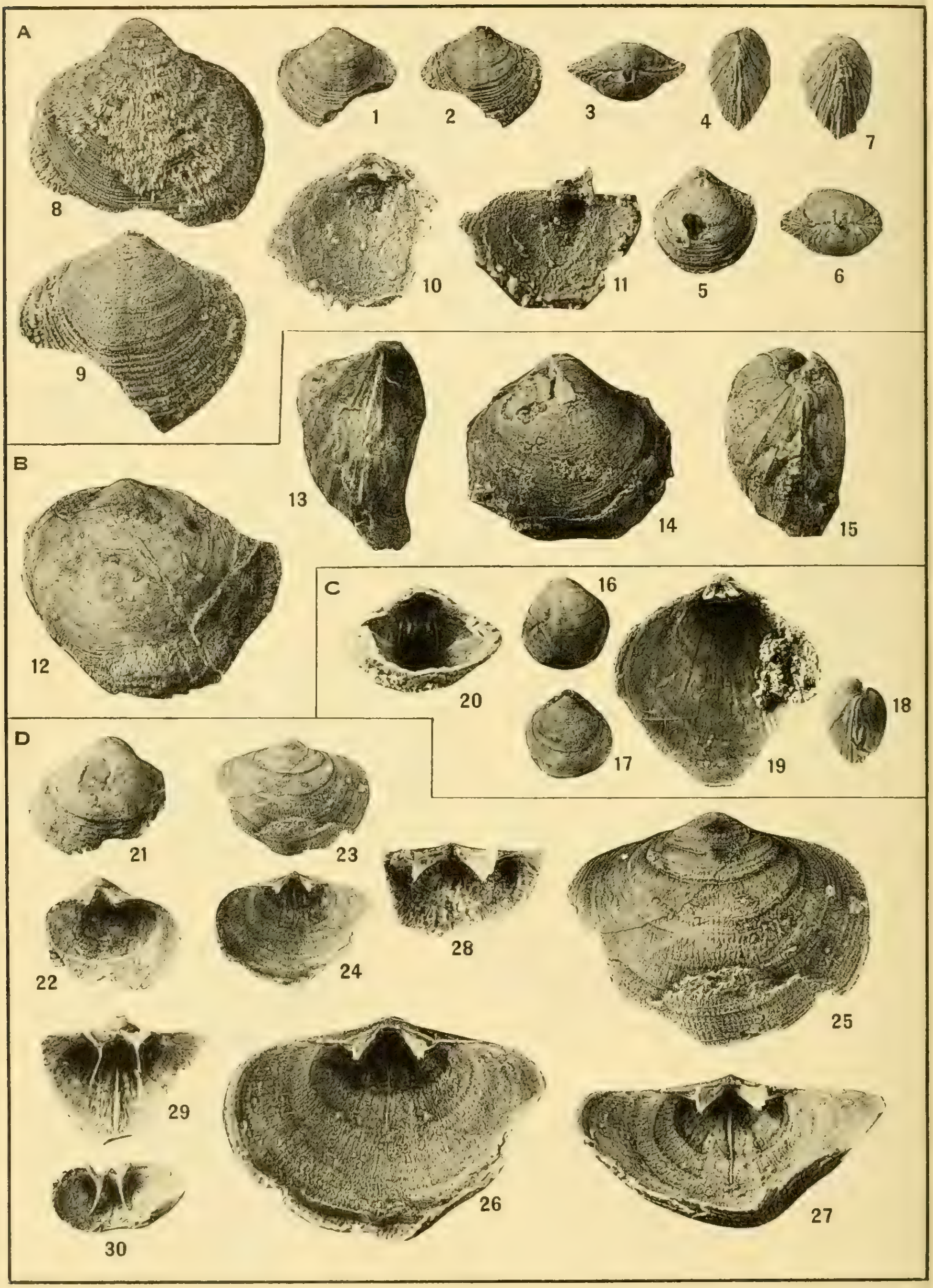
BRACHIOPODA

(SEE EXPLANATION AT END OF TEXT)



BRACHIOPODA

(SEE EXPLANATION AT END OF TEXT)



BRACHIOPODA

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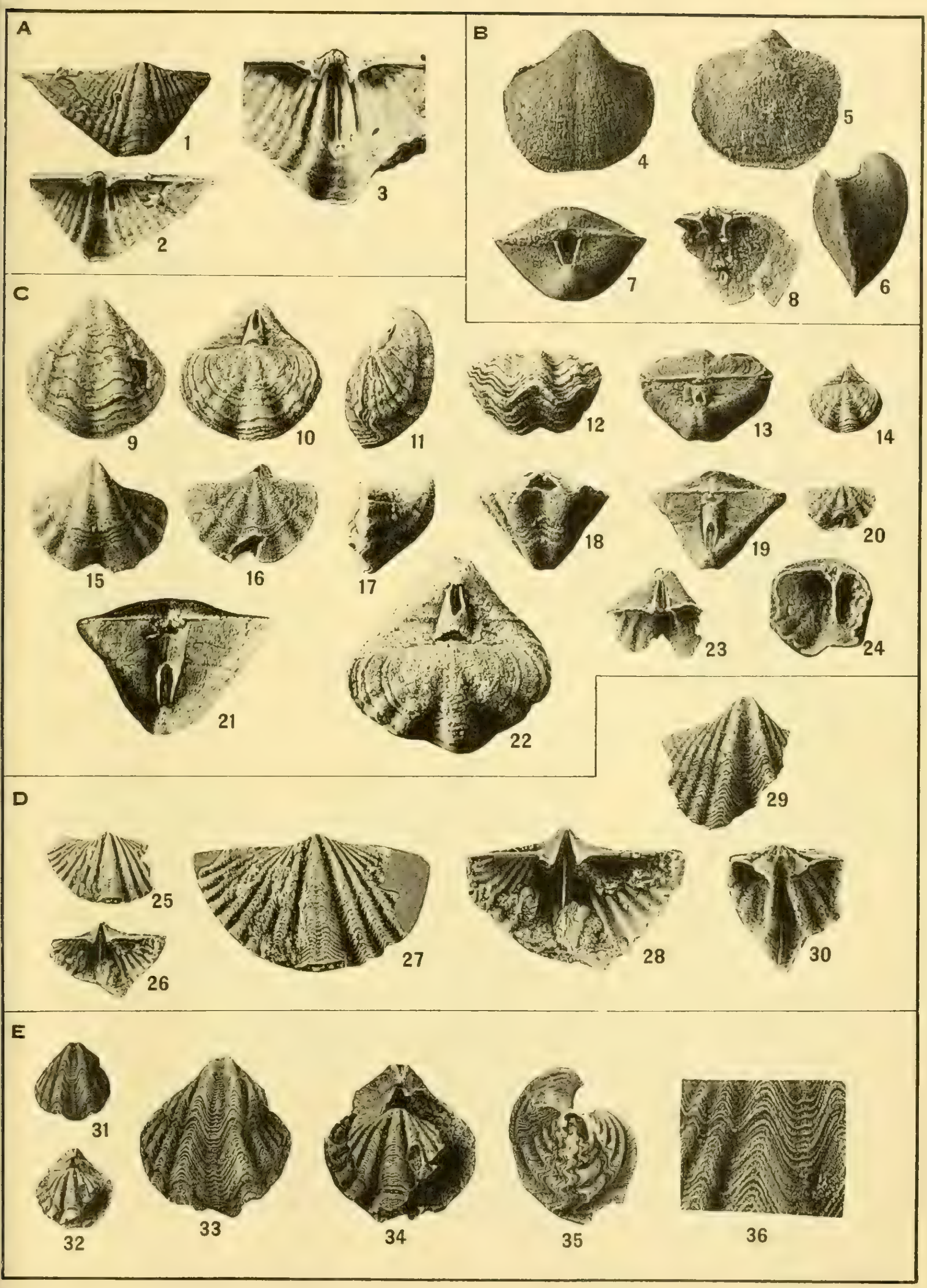
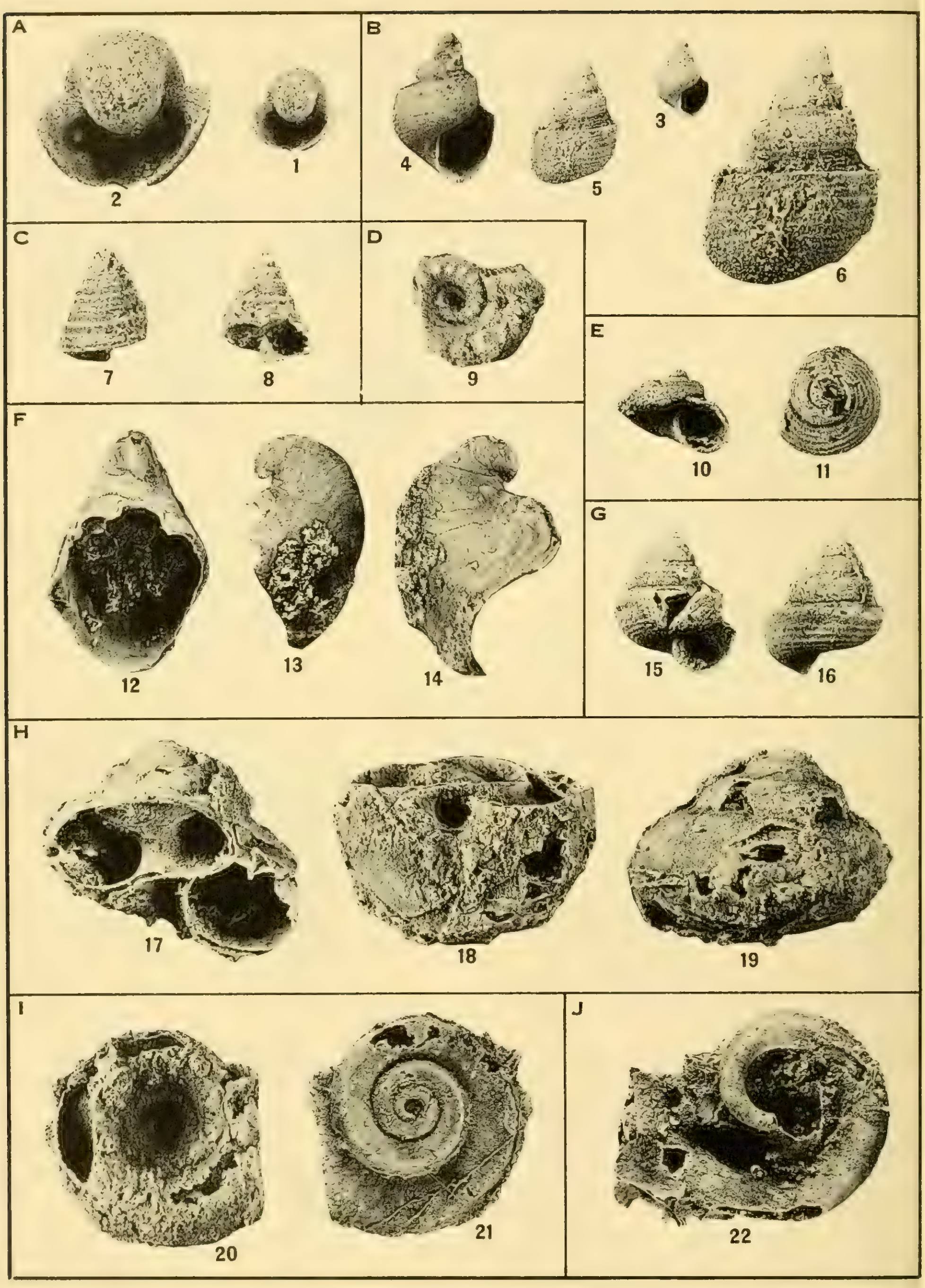


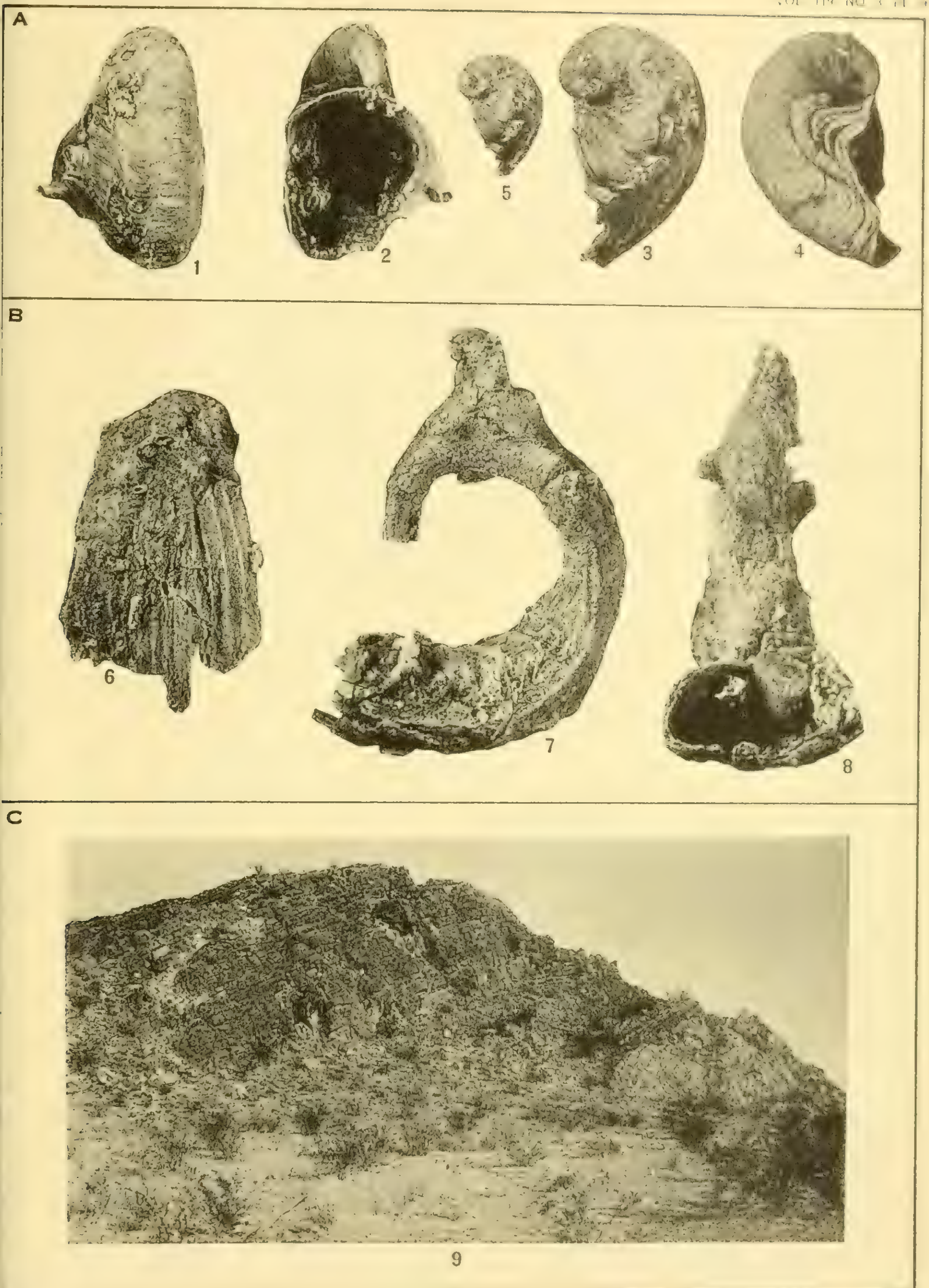
BRACHIOPODA

(SEE EXPLANATION AT END OF TEXT)



GASTROPODA

(SEE EXPLANATION AT END OF TEXT)



GASTROPODA, CEPHALOPODA, AND HILL OF MISSISSIPPIAN REPRESO LIMESTONE

(SEE EXPLANATION AT END OF TEXT)